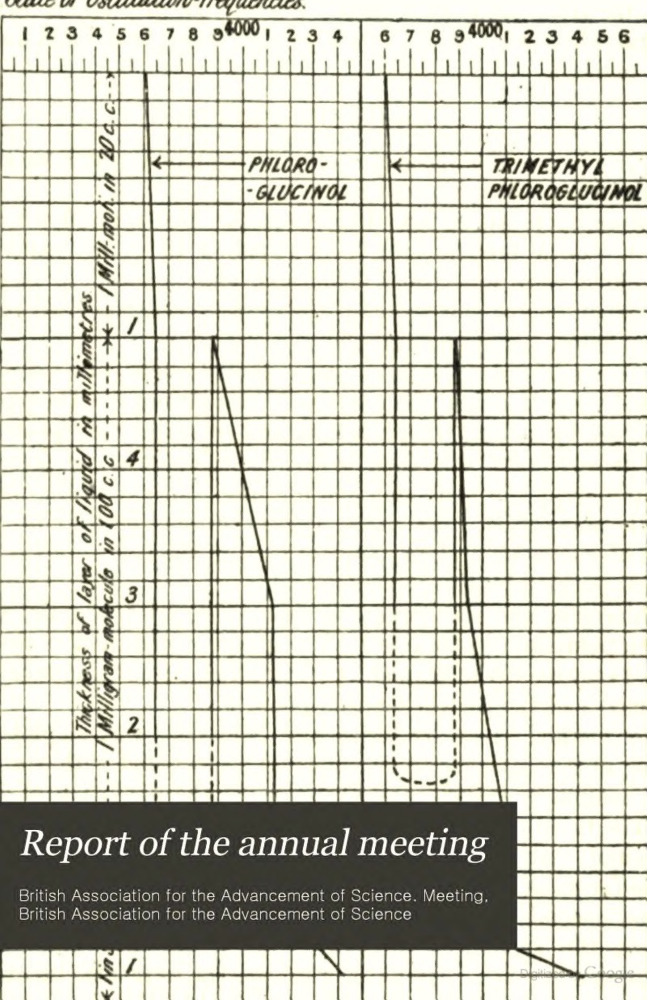

Report of the annual meeting

British Association for the Advancement of Science. Meeting, British Association for the Advancement of Science

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W. G. FARLOW

Presented by the

British Association for the Advancement of Science

REPORT

OF THE

SEVENTY-SECOND MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

HELD AT

BELFAST IN SEPTEMBER 1902.

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CONTENTS.

Page

OBJECTS and Rules of the Association xxix

Places and Times of Meeting, with Presidents, Vice-Presidents, and Local Secretaries from commencement xl

Trustees and General Officers, from 1831 liii

Presidents and Secretaries of the Sections of the Association from 1832 ... liv

List of Evening Discourses lxxiii

Lectures to the Operative Classes lxxvi

Officers of Sectional Committees present at the Belfast Meeting lxxvii

Committee of Recommendations at the Belfast Meeting........................ lxxix

Treasurer's Account lxxx

Table showing the Attendance and Receipts at the Annual Meetings lxxxii

Officers and Council, 1902-1903 lxxxiv

Report of the Council to the General Committee lxxxv

Committees appointed by the General Committee at the Belfast Meeting in September 1902..lxxxviii

Communications ordered to be printed *in extenso* xcvii

Resolutions referred to the Council for consideration, and action if desirable xcvii

Synopsis of Grants of Money xcviii

Places of Meeting in 1903 and 1904 xcix

General Statement of Sums which have been paid on account of Grants for Scientific Purposes c

General Meetings cxviii

Address by the President, Professor JAMES DEWAR, M.A., LL.D., F.R.S.... 3

REPORTS ON THE STATE OF SCIENCE.

[*An asterisk * indicates that the title only is given. The mark † indicates the same, but with a reference to the Journal or Newspaper in which it is published* in extenso.]

Page

Experiments for Improving the Construction of Practical Standards for Electrical Measurements.—Report of the Committee, consisting of Lord RAYLEIGH (Chairman), Dr. R. T. GLAZEBROOK (Secretary), Lord KELVIN, Professors W. E. AYRTON, J. PERRY, W. G. ADAMS, and G. CAREY FOSTER, Sir OLIVER J. LODGE, Dr. A. MUIRHEAD, Sir W. H. PREECE, Professors J. D. EVERETT, A. SCHUSTER, J. A. FLEMING and J. J. THOMSON, Dr. W. N. SHAW, Dr. J. T. BOTTOMLEY, Rev. T. C. FITZPATRICK, Dr. G. JOHNSTONE STONEY, Professor S. P. THOMPSON, Mr. J. RENNIE, Mr. E. H. GRIFFITHS, Sir A. W. RÜCKER, Professor H. L. CALLENDAR, Sir W. C. ROBERTS-AUSTEN, and Mr. GEORGE MATTHEY 53

APPENDIX.—On the Definition of the Unit of Heat 55

Comparing and Reducing Magnetic Observations.—Report of the Committee, consisting of Professor W. G. ADAMS (Chairman), Dr. C. CHREE (Secretary), LORD KELVIN, Professor G. CHRYSTAL, Professor A. SCHUSTER, Captain E. W. CREAK, the ASTRONOMER ROYAL, Mr. WILLIAM ELLIS, and Sir A. W. RÜCKER 58

Seismological Investigations.—Seventh Report of the Committee, consisting of Professor J. W. JUDD (Chairman), Mr. J. MILNE (Secretary), Lord KELVIN, Professor T. G. BONNEY, Mr. C. V. BOYS, Professor G. H. DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Professor J. A. EWING, Dr. R. T. GLAZEBROOK, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Mr. W. E. PLUMMER, Professor J. H. POYNTING, Mr. CLEMENT REID, Mr. NELSON RICHARDSON, and Professor H. H. TURNER. (Drawn up by the Secretary.) 59

I. On Seismological Stations abroad and in Great Britain............ 59
II. The Instruments in use at Shide 60
III. The Origins of the Earthquakes recorded in 1899, 1900, and 1901 61
IV. Duration of the First Preliminary Tremors 64
V. Time Curves for Earthquakes recorded during the four years ending December 31, 1900 65
VI. The Comparison of the Records obtained from three horizontal pendulums at Shide 68
VII. Clinometric Experiments.. 70
VIII. Vertical Spring Seismograph Experiments 71
IX. On the Nature of Earthquake Movement 71
X. Relationship between Rockfolding, Seismic, and Volcanic Activities. 72
XI. On the Comparison of Earthquake Registers from Shide, Kew, Bidston, and Edinburgh 73
XII. Experiments at the Ridgeway Fault. By HORACE DARWIN ... 75

Page

Magnetic Observations at Falmouth.—Report of the Committee, consisting of Sir W. H. Preece (Chairman), Dr. R. T. Glazebrook (Secretary), Professor W. G. Adams, Captain Creak, Mr. W. L. Fox, Professor A. Schuster, and Sir A. W. Rücker, appointed to co-operate with the Committee of the Falmouth Observatory in their Magnetic Observations 75

Investigation of the Upper Atmosphere by Means of Kites in co-operation with a Committee of the Royal Meteorological Society.—Report of the Committee, consisting of Dr. W. N. Shaw (Chairman), Mr. W. H. Dines (Secretary), Mr. D. Archibald, Mr. C. Vernon Boys, Dr. A. Buchan, and Dr. H. R. Mill 77

Report on the Theory of Point-groups.—Part II. By Frances Hardcastle 81

Meteorological Observations on Ben Nevis.—Report of the Committee, consisting of Lord M'Laren, Professor A. Crum Brown (Secretary), Sir John Murray, Professor Copeland, and Dr. Alexander Buchan. (Drawn up by Dr. Buchan.) 93

Statistics concerning the Training of Chemists employed in English Chemical Industries.—Report of the Committee, consisting of Professor W. H. Perkin (Chairman), Professor G. G. Henderson (Secretary), Professor H. E. Armstrong, and Mr. G. T. Beilby. 97

Absorption Spectra and Chemical Constitution of Organic Substances.—Fourth Interim Report of the Committee, consisting of Professor W. Noel Hartley (Chairman and Secretary), Professor F. R. Japp, Professor J. J. Dobbie, and Mr. Alexander Lauder, appointed to investigate the Relation between the Absorption Spectra and Chemical Constitution of Organic Substances 99

- Part I.—The Absorption Spectra of Phloroglucinol and some of its Derivatives. By W. N. Hartley, D.Sc., F.R.S., James J. Dobbie, D.Sc., M.A., and Alexander Lauder, B.Sc. 99
- Part II.—On the Curves of Molecular Vibrations of Quinone, p-Nitroso-phenol and similarly derived Substances 107

Hydro-aromatic Compounds with Single Nucleus. By Arthur W. Crossley, D.Sc., Ph.D. 120

Wave-length Tables of the Spectra of the Elements and Compounds.—Report of the Committee, consisting of Sir H. E. Roscoe (Chairman), Dr. Marshall Watts (Secretary), Sir J. N. Lockyer, Professor J. Dewar, Professor G. D. Liveing, Professor A. Schuster, Professor W. N. Hartley, Professor Wolcott Gibbs, and Captain Sir W. de W. Abney 137

The Nature of Alloys.—Report of the Committee, consisting of Mr. F. H. Neville (Chairman and Secretary), Mr. C. T. Heycock, and Mr. E. H. Griffiths. 175

Isomeric Naphthalene Derivatives.—Report of the Committee, consisting of Professor W. A. Tilden (Chairman) and Dr. H. E. Armstrong (Secretary). (Drawn up by the Secretary.) 176

Isomorphous Sulphonic Derivatives of Benzene.—Third Report of the Committee, consisting of Professor H. A. Miers (Chairman), Dr. H. E. Armstrong (Secretary), Dr. W. P. Wynne, and Mr. W. J. Pope. (Drawn up by the Secretary.) 180

Our Present Knowledge of Aromatic Diazo-compounds. By Gilbert Thomas Morgan, D.Sc., F.I.C. 181

Registration of Type Specimens of British Fossils.—Report of the Committee, consisting of Dr. H. Woodward (Chairman), Dr. A. Smith Woodward (Secretary), Rev. G. H. Whidborne, Mr. R. Kidston, Professor H. G. Seeley, Mr. H. Woods, and Rev. J. F. Blake................................. 210

Page

Life-zones in the British Carboniferous Rocks.—Report of the Committee, consisting of Mr. J. E. Marr (Chairman), Dr. Wheelton Hind (Secretary), Mr. F. A. Bather, Mr. G. C. Crick, Dr. A. H. Foord, Mr. H. Fox, Professor E. J. Garwood, Dr. G. J. Hinde, Professor P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. B. N. Peach, Mr. A. Strahan, and Dr. H. Woodward. (Drawn up by the Secretary.) 210

A List of the Fish Fauna of the Pendleside Limestones, with Remarks on the Evidence which may be adduced from such List in support of the Systematic Position of the Rocks. By Edgar D. Wellburn, F.G.S. 222

The Movements of Underground Waters of North-west Yorkshire.—Third Report of the Committee, consisting of Professor W. W. Watts (Chairman), Mr. A. R. Dwerryhouse (Secretary), Professor A. Smithells, Rev. E. Jones, Mr. Walter Morrison, Mr. G. Bray, Rev. W. Lower Carter, Mr. T. Fairley, Mr. P. F. Kendall, and Mr. J. E. Marr 224

Photographs of Geological Interest in the United Kingdom.—Thirteenth Report of the Committee, consisting of Professor James Geikie (Chairman), Professor W. W. Watts (Secretary), Professor T. G. Bonney, Professor E. J. Garwood, Dr. Tempest Anderson, Mr. Godfrey Bingley, Mr. H. Coates, Mr. C. V. Crook, Mr. J. G. Goodchild, Mr. William Gray, Mr. Robert Kidston, Mr. A. S. Reid, Mr. J. J. H. Teall, Mr. R. Welch, Mr. H. B. Woodward, and Mr. F. Woolnough. (Drawn up by the Secretary.) 229

Kesh Caves, co. Sligo.—Report of the Committee, consisting of Dr. R. F. Scharff (Chairman), Mr. R. Ll. Praeger (Secretary), Mr. G. Coffey, Professor G. A. J. Cole, Professor D. J. Cunningham, Mr. G. W. Lamplugh, Mr. A. McHenry, and Mr. R. J. Ussher, appointed to explore Irish Caves. (Drawn up by the Chairman.) 247

Erratic Blocks of the British Isles.—Report of the Committee, consisting of Mr. J. E. Marr (Chairman), Mr. P. F. Kendall (Secretary), Professor T. G. Bonney, Mr. C. E. De Rance, Professor W. J. Sollas, Mr. R. H. Tiddeman, Rev. S. N. Harrison, Dr. J. Horne, Mr. F. M. Burton, Mr. J. Lomas, Mr. A. R. Dwerryhouse, Mr. J. W. Stather, Mr. W. T. Tucker, and Mr. F. W. Harmer, appointed to investigate the Erratic Blocks of the British Isles, and to take measures for their preservation. (Drawn up by the Secretary.) 252

Schedule........ *To face page* 258

Occupation of a Table at the Zoological Station at Naples.—Report of the Committee, consisting of Professor W. A. Herdman (Chairman), Professor G. B. Howes (Secretary), Professor E. Ray Lankester, Professor W. F. R. Weldon, Professor S. J. Hickson, Mr. A. Sedgwick, and Professor W. C. McIntosh 259

Appendix I.—Report on the Occupation of the Table: *a.* On the Structure and Development of the Excretory Apparatus of Amphioxus. By E. S. Goodrich, M.A. 260

b. On Trematodes and Cestodes parasitic on Fishes. By Norman Maclaren 260

c. On the Algæ of the Bay of Naples. By Miss Anna Vickers 262

d. On the Copepod Sub-family Ætidiinæ, with a proposed Revision of the Classification. By R. Norris Wolfenden, M.D. Cantab., F.Z.S. 263

„ II.—A List of Naturalists who have worked at the Zoological Station from the end of June 1901 till the end of June 1902 267

Page

APPENDIX III.—A List of Papers which were published in the Year 1901 by the Naturalists who have occupied Tables in the Zoological Station ... 269

„ IV.—A List of the Publications of the Zoological Station during the Year ending June 30, 1902 ... 270

Investigations made at the Marine Biological Laboratory, Plymouth.—Report of the Committee, consisting of Mr. W. GARSTANG (Chairman and Secretary), Dr. E. RAY LANKESTER, Professor SYDNEY H. VINES, Mr. A. SEDGWICK, and Professor W. F. R. WELDON. (Drawn up by the Secretary.) ... 271

Investigations in the Laboratory of the Marine Biological Association of the West of Scotland at Millport.—Report of the Committee, consisting of Sir JOHN MURRAY (Chairman), Dr. J. F. GEMMILL (Secretary), Professors BOWER, COSSAR EWART, W. A. HERDMAN, and M. LAURIE, and Messrs. ALEX. SOMERVILLE and J. A. TODD ... 272

Bird Migration in Great Britain and Ireland.—Fifth Interim Report of the Committee, consisting of Professor NEWTON (Chairman), Rev. E. P. KNUBLEY (Secretary), Mr. JOHN A. HARVIE-BROWN, Mr. R. M. BARRINGTON, Mr. A. H. EVANS, and Dr. H. O. FORBES, appointed to work out the details of the Observations on the Migration of Birds at Lighthouses and Lightships, 1880–1887 ... 273

Index Generum et Specierum Animalium.—Report of the Committee, consisting of Dr. H. WOODWARD (Chairman), Dr. F. A. BATHER (Secretary), Dr. P. L. SCLATER, Rev. T. R. R. STEBBING, Mr. R. McLACHLAN, and Mr. W. E. HOYLE ... 283

Coral Reefs of the Indian Region.—Third Report of the Committee, consisting of Mr. A. SEDGWICK (Chairman), Professor J. GRAHAM KERR (Secretary), Professor J. W. JUDD, Mr. J. J. LISTER, Mr. FRANCIS DARWIN, Dr. S. F. HARMER, and Professors A. MACALISTER, W. A. HERDMAN, and S. J. HICKSON, appointed to investigate the Structure, Formation, and Growth of the Coral Reefs of the Indian Region ... 284

The Zoology of the Sandwich Islands.—Twelfth Report of the Committee, consisting of Professor A. NEWTON (Chairman), Mr. DAVID SHARP (Secretary), Dr. W. T. BLANFORD, Professor S. J. HICKSON, Dr. P. L. SCLATER, Dr. F. DU CANE GODMAN, and Mr. EDGAR A. SMITH ... 284

Terrestrial Surface-waves and Wave-like Surfaces.—Second Report of the Committee, consisting of Dr. J. SCOTT KELTIE (Chairman), Dr. VAUGHAN CORNISH (Secretary), Lieut.-Col. BAILEY, Mr. E. A. FLOYER, and Mr. W. H. WHEELER. (Drawn up by the Secretary.) ... 285

Women's Labour.—Second Report of the Committee, consisting of Mr. E. W. BRABROOK (Chairman), Mr. A. L. BOWLEY (Secretary), Dr. CHARLES BOOTH, Professor S. J. CHAPMAN, Miss C. E. COLLET, Professor F. Y. EDGEWORTH, Professor A. W. FLUX, Mrs. J. R. MACDONALD, Mr. L. L. PRICE, and Professor W. SMART, appointed to investigate the Economic Effect of Legislation regulating Women's Labour ... 286

APPENDIX I.—Report on the Cotton Industry of Lancashire. By Professor S. J. CHAPMAN ... 287

„ II.—Report on the West Riding of Yorkshire. By Mr. A. L. BOWLEY ... 291

„ III.—Report on Birmingham. By Miss B. L. HUTCHINS ... 296

„ IV.—Report on the Boot and Shoe Trades of Bristol and Kingswood. By Mr. G. H. WOOD ... 299

„ V.—On Leicester and Northampton. Compiled from Report by Mr. R. HALSTEAD ... 304

„ VI.—On Canning Town and the Isle of Dogs. Abstract of Report by Miss HADLEY ... 305

Page

Appendix VII.—Switzerland: Federal Legislation. Cantonal Legislation 306
„ VIII.—Holland 308
„ IX.—Grand Duchy of Luxembourg 309
„ X.—Hungary 309
„ XI.—Finland 310
„ XII.—Russia 310
„ XIII.—Sweden 310
„ XIV.—Norway 310
„ XV.—Denmark 311

The Resistance of Road Vehicles to Traction.—Report of the Committee, consisting of Sir Alexander Binnie (Chairman), Professor H. S. Hele-Shaw (Secretary), Mr. T. Aitken, Mr. T. C. Aveling (Treasurer), Professor T. Hudson Beare, Mr. W. Worby Beaumont, Mr. J. Brown, Colonel R. E. Crompton, Sir D. Salomons, Mr. A. R. Sennett, Sir J. I. Thornycroft, and Mr. W. H. Wheeler. (Drawn up, at the request of the Committee, by the Secretary, assisted by Mr. J. F. Gill, B.Sc.) 314

I. Preface 314
II. The Works of Corréze and Manès (1832) 314
III. The Work of Coriolis (1835) 315
IV. Experiments and Conclusions of General Morin (1837–42) 316
V. The Researches of M. Dupuit 323
VI. Theoretical Investigation by Edmund Leahy, C.E. (1847) 326
VII. The Work of M. Charié-Marsaines 329
VIII. Experiments by A. Michelin (1896) 330
IX. Extract from the Report of Professor W. C. Unwin, F.R.S., on the Trials of Self-moving Vehicles at Birmingham made before the Royal Agricultural Society (1897) 336
X. Experiments by Professor H. S. Hele-Shaw, F.R.S. (1897) 337
XI. Investigations of Professor Ira O. Baker (1902) 338
XII. Summary of the Opinions of various Writers on the Relation between Tractive Effort and the various Independent Elements of Road Resistance 343
XIII. Description and Drawings of the New Dynamometer made for the British Association Committee to carry on the Researches 345
XIV. Nature and Scope of the Experiments by the Committee 346
XV. The Work of the Committee presented at the Meeting 347

Small Screw Gauge.—Report of the Committee, consisting of Sir W. H. Preece (Chairman), Mr. W. A. Price (Secretary), Lord Kelvin, Sir F. J. Bramwell, Sir H. Trueman Wood, Major-General Webber, Colonel Watkin, Lieut.-Colonel Crompton, Messrs. A. Stroh, A. Le Neve Foster, C. J. Hewitt, G. K. B. Elphinstone, E. Rigg, C. V. Boys, J. Marshall Gorham, O. P. Clements, and W. Taylor, Dr. R. T. Glazebrook, and Mr. Mark Barr, appointed to consider means by which Practical Effect can be given to the introduction of the Screw Gauge proposed by the Association in 1884 350

Anthropometric Investigations among the Native Troops of the Egyptian Army.—Interim Report of the Committee, consisting of Professor A. Macalister (Chairman), Dr. C. S. Myers (Secretary), Sir John Evans, and Professor D. J. Cunningham 350

Pigmentation Survey of the School Children of Scotland.—Report of the Committee, consisting of Mr. E. W. Brabrook (Chairman), Mr. J. Gray (Secretary), Dr. A. C. Haddon, Professor A. Macalister, Professor D. J. Cunningham, Mr. J. F. Tocher, and Dr. W. H. R. Rivers. (Drawn up by the Secretary) 352

Page

Ethnological Survey of Canada.—Report of the Committee, consisting of Professor D. P. PENHALLOW (Chairman), Mr C. HILL-TOUT (Secretary), Mr. E. W. BRABROOK, Dr. A. C. HADDON, Mr. E. S. HARTLAND, Professor E. B. TYLOR, Sir JOHN BOURINOT, Mr. B. SULTE, Mr. DAVID BOYLE, Mr. C. N. BELL, Professor JOHN MAVOR, Mr. C. F. HUNTER, Dr. W. F. GANONG, and Rev. JOHN CAMPBELL ... 353

Anthropological Photographs.—Interim Report of the Committee, consisting of Mr. C. H. READ (Chairman), Mr. J. L. MYRES (Secretary), Dr. J. G. GARSON, Mr. H. LING ROTH, Mr. H. BALFOUR, Mr. E. S. HARTLAND, and Professor FLINDERS PETRIE, appointed for the Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest ... 449

The Roman Fort at Gellygaer.—Report of the Committee, consisting of Professor J. RHYS (Chairman), Mr. J. L. MYRES (Secretary), Mr. A. J. EVANS, and Mr. E. W. BRABROOK, appointed to co-operate with the Cardiff Naturalists' Society in its Excavations on the Site of a Roman Fort at Gellygaer ... 450

Silchester Excavation.—Report of the Committee, consisting of Mr. ARTHUR J. EVANS (Chairman), Mr. J. L. MYRES (Secretary), and Mr. E. W. BRABROOK, appointed to co-operate with the Silchester Excavation Fund Committee in their Excavations ... 453

The Age of Stone Circles.—Report of the Committee, consisting of Dr. J. G. GARSON (Chairman), Mr. H. BALFOUR (Secretary), Sir JOHN EVANS, Mr. C. H. READ, Professor R. MELDOLA, Mr. A. J. EVANS, Dr. R. MUNRO, Professor BOYD DAWKINS, and Mr. A. L. LEWIS, appointed to conduct Explorations with the object of Ascertaining the Age of Stone Circles. (Drawn up by the Secretary.) ... 455

On the Excavations at Arbor Low, May–June 1902. By H. ST. GEORGE GRAY ... 455

On Explorations at Knossos in Crete.—Report of the Committee, consisting of Sir JOHN EVANS (Chairman), Mr. J. L. MYRES (Secretary), Mr. A. J. EVANS, Mr. D. G. HOGARTH, Professor A. MACALISTER, and Professor W. RIDGEWAY. (Drawn up by Mr. A. J. EVANS.) ... 466

Work of the Mammalian Heart.—Report of the Committee, consisting of Professor J. G. MCKENDRICK (Chairman), Dr. T. G. BRODIE (Secretary), and Professor W. H. THOMPSON, appointed to Study the Power of the Mammalian Heart for performing Work under varying External Conditions and under the Influence of Drugs. (Drawn up by the Secretary) ... 470

The Micro-chemistry of Cells.—Report of the Committee, consisting of Professor E. A. SCHÄFER (Chairman), Professor A. B. MACALLUM (Secretary), Professor E. RAY LANKESTER, Professor W. D. HALLIBURTON, Mr. G. C. BOURNE, and Professor J. J. MACKENZIE. (Drawn up by the Secretary.) ... 470

Botanical Photographs.—Report of the Committee, consisting of Professor L. C. MIALL (Chairman), Professor F. E. WEISS (Secretary), Mr. FRANCIS DARWIN, and Professor G. F. SCOTT-ELLIOT, appointed to consider and report upon a scheme for the registration of Negatives of Botanical Photographs ... 471

APPENDIX.—Arrangements in existence for the Preservation and Registration of Photographs of Anthropological and Geological Interest ... 472

Investigation on the Respiration of Plants.—Report of the Committee, consisting of Professor H. MARSHALL WARD (Chairman), Mr. HAROLD WAGER (Secretary), Mr. FRANCIS DARWIN, and Professor J. B. FARMER ... 472

Page

Investigation of the Cyanophyceæ.—Report of the Committee, consisting of Professor J. B. FARMER (Chairman), Dr. F. F. BLACKMAN (Secretary), Professor MARSHALL WARD, and Mr. W. GARDINER ... 473

Teaching of Elementary Mathematics.—Report of the Committee, consisting of Professor FORSYTH (Chairman), Professor PERRY (Secretary), Professor CHRYSTAL, Mr. W. D. EGGAR, Mr. H. W. EVE, Professor GIBSON, Dr. GLADSTONE, Professor GREENHILL, Professor R. A. GREGORY, Professor HENRICI, Professor HUDSON, Dr. LARMOR, Professor A. LODGE, Sir O. LODGE, Professor LOVE, Major MACMAHON, Professor MINCHIN, Sir A. W. RÜCKER, Mr. ROBERT RUSSELL, and Professor S. P. THOMPSON, appointed to report upon improvements that might be effected in the teaching of Mathematics, in the first instance in the teaching of Elementary Mathematics, and upon such means as they think likely to effect such improvements. (Drawn up by the Chairman.) ... 473

APPENDIX.—Two Suggested Schedules of Experimental Geometry ... 478

The Teaching of Science in Elementary Schools.—Report of the Committee, consisting of Dr. J. H. GLADSTONE (Chairman), Professor H. E. ARMSTRONG (Secretary), Lord AVEBURY, Professor W. R. DUNSTAN, Mr. GEORGE GLADSTONE, Sir PHILIP MAGNUS, Sir H. E. ROSCOE, Professor A. SMITHELLS, and Professor S. P. THOMPSON ... 481

On the Conditions of Health essential to the Carrying-on of the Work of Instruction in Schools.—Report of the Committee, consisting of Professor C. S. SHERRINGTON (Chairman), Mr. E. WHITE WALLIS (Secretary), Mr. E. W. BRABROOK, Dr. C. W. KIMMINS, Professor L. C. MIALL, and Professor H. L. WITHERS ... 483

TRANSACTIONS OF THE SECTIONS.

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

THURSDAY, SEPTEMBER 11.

Page

Address by Professor John Purser, M.A., LL.D., M.R.I.A., President of the Section 499

1. *On the Question as to the Accurate Conservation of Weight in Chemical Reactions. By Lord Rayleigh, F.R.S. 511
2. *Motion of a Detached Thread of Liquid in a Capillary Tube. By Professor W. B. Morton, M.A., and W. Hawthorn 511
3. *On the Vibrations of a Plucked String. By Professor W. B. Morton, M.A., and T. B. Vinycomb 511
4. *On Continuous Motion produced by Vibrations. By Professor W. B. Morton, M.A., and A. M. Kinsky 511
5. *On the Prevention of a Deposit of Dew on the Lenses of a Projecting Lantern. By Professor A. Schuster, F.R.S. 511
6. Further Experiments by the Thermal Method on the Variation of the Critical Velocity of Water with Temperature. By Howard T. Barnes, M.A.Sc., D.Sc. 512

FRIDAY, SEPTEMBER 12.

Department II.—Astronomy and Cosmical Physics.

Address by Professor A. Schuster, Ph.D., F.R.S., Chairman 512

*Discussion on the Nebula surrounding Nova Persei, opened by A. R. Hinks with an Exhibition of some Photographs from the Yerkes and Lick Observatories 521

1. New Solar Radiation Recorder. By Dr. W. E. Wilson, F.R.S. 521
2. Search for ultra-Neptunian Planet. By Dr. W. E. Wilson, F.R.S. 521
3. Minimum Sun-spots and Terrestrial Magnetism. By the Rev. A. L. Cortie, S.J., F.R.A.S. 522

MONDAY, SEPTEMBER 15.

Department I.—Mathematics.

1. Report on the Present State of the Theory of Point Groups (p. 81) 523
2. On the Partial Differential Equations of Mathematical Physics. By E. T. Whittaker, M.A. 523

Page
3. The Longitudinal Stability of Aërial Gliders. By Professor G. H. BRYAN, Sc.D., F.R.S. 524
4. On Map-colouring. By Professor A. C. DIXON, Sc.D. 525
5. On the Newtonian Potential. By Professor A. C. DIXON, Sc.D. 526
6. The Discriminant of a Family of Curves or Surfaces. By Professor BROMWICH, M.A., and R. W. H. T. HUDSON, M.A. 526
7. Matrix Notation in the Theory of Screws. By R. W. H. T. HUDSON, M.A. 528
8. On Pluperfect Numbers. By Lieut.-Colonel ALLAN CUNNINGHAM, R.E. 528
9. *On a Practical Rule for finding the Perimeter of an Ellipse. By THOMAS MUIR, C.M.G., F.R.S. 529
10. The late J. Hamblin Smith's Rule for the Decimalisation of English Money. By J. D. HAMILTON DICKSON 529
11. *A Theorem in Determinants. By A. A. ROBB 530

DEPARTMENT II.—PHYSICS.

1. Note on the Variation of the Specific Heat of Mercury with Temperature: Experiments by the Continuous-flow Method of Calorimetry. By HOWARD T. BARNES, M.A.Sc., D.Sc., and H. LESTER COOKE, B.A. 530
2. Some Experiments on Radiation and Absorption: a Preliminary Study for a Standard of Light. By J. E. PETAVEL 534
3. Some Observations on Equations of State. By H. H. F. HYNDMAN 535
4. *On the Graphical Representation of Ramsay and Young's Law for the Comparison of Vapours at Equal Pressures. By Professor J. D. EVERETT, F.R.S. 537
5. Dependence of Pitch of Minute Closed Pipes on Wind Pressure. By C. S. MYERS, M.D. 537
6. A Lens for Ultra-violet Therapy. By J. WILLIAM GIFFORD 537
7. Mr. Petavel's Recording Gauge applied to Ordnance and Small Arms. By Captain J. BRUCE-KINGSMILL, R.A. 538
8. On an Improvement upon Huygens' Construction. By G. JOHNSTONE STONEY, M.A., D.Sc., F.R.S. 539
9. How to apply the Resolution of Light into Undulations of Flat Wavelets to the Investigation of Optical Phenomena. By G. JOHNSTONE STONEY, M.A., D.Sc., F.R.S. 539

DEPARTMENT III.—ASTRONOMY AND COSMICAL PHYSICS.

1. *Illustrations obtained by Photography of the Evolution of Stellar Systems. By ISAAC ROBERTS, D.Sc. F.R.S. 541
2. Radiation in Meteorology. By W. N. SHAW, D.Sc., F.R.S. 541
3. On the Figure of the Earth. By Major S. G. BURRARD, R.E. 541
4. Report on Seismological Investigations (p. 59) 542
5. Report on the Investigation of the Upper Atmosphere by Means of Kites (p. 77) 542
6. Report on Magnetic Observations at Falmouth Observatory (p. 75) 542
7. Report on Meteorological Observations on Ben Nevis (p. 93) 543
8. Report on the Comparison and Reduction of Magnetic Observations (p. 58) 543

TUESDAY, SEPTEMBER 16.

DEPARTMENT I.—PHYSICS.

Page
1. Animal Thermostat. By Lord KELVIN 543
2. On the Application of the Method of Entropy to Radiant Energy. By J. LARMOR, D.Sc., Sec.R.S. 546
3. On the Relation of Voltaic Potential Differences to Temperature. By J. LARMOR, D.Sc., Sec.R.S. 546
4. *Does Motion through the Ether cause Double Refraction? By Lord RAYLEIGH, F.R.S. 546
5. Report on Electrical Standards (p. 53) 546
6. Magnetic Detectors in Space Telegraphy. By Professor ERNEST WILSON 547
7. A new Receiver for Hertzian Oscillations. By Professor G. M. MINCHIN, F.R.S. 547
8. A Graphical Method of Determining the Discharge Curve of a Condenser through a variable Self-induction. By E. W. MARCHANT, D.Sc. 548
9. On Luminosity and the Kinetic Theory. By J. BUTLER BURKE, M.A.... 549
10. The Physical Aspects of a Theory of Colour Vision. By F. W. EDRIDGE-GREEN, M.D., F.R.C.S. 549
11. Light Aluminium Tubes. By F. H. NALDER 551

DEPARTMENT II.—ASTRONOMY AND COSMICAL PHYSICS.

1. *Exhibition of Celestial Photographs from the Yerkes Observatory. By A. R. HINKS, M.A. 551
2. Possible Changes on the Lunar Surface. By S. A. SAUNDER, M.A. 551
3. The Relative Apparent Motions of Bright and Faint Stars. By Professor H. H. TURNER, F.R.S. 552
4. A Standard Scale for Telescopic Observations. By PERCIVAL LOWELL... 553
5. Expedition for ascertaining the best Location of Observatories. By PERCIVAL LOWELL 554
6. Spectrograms of Jupiter, Uranus, and Vesta. By PERCIVAL LOWELL ... 555
7. The Uncertainty of our present Knowledge of the Distance of the Sun. By A. R HINKS, M.A. 555
8. *The Positions of Hydrogen and Helium in Relation to the Earth's Atmosphere. By Professor G. H. BRYAN, F.R.S. 556

SECTION B.—CHEMISTRY.

THURSDAY, SEPTEMBER 11.

Address by Professor EDWARD DIVERS, M.D., F.R.S., V.P.C.S., President of the Section 557
1. *On the Corrosion of Copper by Sea-water, and on the Detection of Traces of Impurity in the Commercial Metal. By Professor E. A. LETTS, Ph.D. 576

Page
2. *On Experiments to Ascertain the Amount of Carbonic Anhydride absorbed from the Sea-water by Air. By Professor E. A. LETTS, Ph.D., and W. CALDWELL, B.A. 576
3. The Action of Distilled Water upon Lead. By Professor FRANK CLOWES, D.Sc. 576

FRIDAY, SEPTEMBER 12.

1. Hydro-aromatic Compounds with Single Nucleus. By A. W. CROSSLEY, D.Sc., Ph.D. (p. 120) 577
2. The Undesirability of Establishing Standard Analytical Methods. By BERTRAM BLOUNT 577
3. The Decomposition of Urea. By CHARLES E. FAWSITT, Ph.D. 578
4. Report on the Relation between the Absorption Spectra and Chemical Constitution of Organic Substances (p. 99) 578
5. Recent Synthetical Researches in the Glucoside Group. By Dr. E. FRANKLAND ARMSTRONG 578
6. The Synthetical Action of Enzymes. By Dr. E. FRANKLAND ARMSTRONG 579
7. The Telluric Distribution of the Elements in Relation to their Atomic Weights. By WILLIAM ACKROYD, F.I.C. 581

MONDAY, SEPTEMBER 15.

1. Our Present Knowledge of Aromatic Diazo-compounds. By GILBERT THOMAS MORGAN, D.Sc., F.I.C. (p. 181) 581
2. The Colour of Iodine-containing Compounds. By Miss IDA SMEDLEY ... 582
3. On a Fourth Methylmorphimethine. By J. HAWTHORNE, B.A. 582
4. The Alkylation of Sugars. By THOMAS PURDIE, F.R.S., and JAMES C. IRVINE, B.Sc., Ph.D. 583
5. Report on the Collection of Statistics concerning the Training of Chemists employed in English Chemical Industries (p. 97) 584
6. Report on Isomeric Naphthalene Derivatives (p. 176) 584
7. Report on Isomeric Sulphonic Derivatives of Benzene (p. 180) 584
8. The Reduction of some Metallic Chlorides by Calcium Carbide. By Major W. E. EDWARDS, R.A., Captain C. H. LIVEING, R.A., and Professor W. R. HODGKINSON, Ph.D., F.I.C., F.R.S.E. 585

TUESDAY, SEPTEMBER 16.

1. Colloids of Zirconium, compared with those of other Metals of the Fourth Group. By Dr. J. H. GLADSTONE, F.R.S., and WALTER HIBBERT, F.I.C. 585
2. On Fluorescent and Phosphorescent Diamonds. By Dr. J. H. GLADSTONE, F.R.S. 586
3. Acid Esters of Methyl Succinic Acids. By Professor J. J. SUDBOROUGH, Ph.D., D.Sc., and WILLIAM A. BONE, Ph.D., D.Sc. 586
4. Compounds of Trinitrobenzene with Alkylated Arylamines. By H. HIBBERT, M.Sc., and Professor J. J. SUDBOROUGH, Ph.D., D.Sc. 587

Page

5. Action of Alkalis on Cinnamic Acid Dibromide and its Esters. By Professor J. J. Sudborough, Ph.D., D.Sc., and K. J. Thompson, B.Sc. ... 587

6. *On the Absorption of Ammonia from Water by Algæ. By Professor E. A. Letts, Ph.D., and J. S. Totton 587

7. *On Determinations of Atmospheric Carbonic Anhydride made on board the 'Discovery' on the Voyage to the Cape and thence to New Zealand. By Professor E. A. Letts, Ph.D. 587

8. *A New Method of causing Isomerisation. By Professor Raphael Meldola, F.R.S., V.P.C.S. 587

9. *Interim Report on the Action of Gases dissolved in Metals and Alloys on their Properties 588

10. Report on the Nature of Alloys (p. 175) 588

11. Report on Preparing a New Series of Wave-length Tables of the Spectra of the Elements (p. 137) 588

Section C.—GEOLOGY.

THURSDAY, SEPTEMBER 11.

Address by Lieut.-Gen. C. A. McMahon, F.R.S., V.P.G.S., President of the Section 589

1. The Geology of the Country in the Neighbourhood of Belfast. By Professor Grenville A. J. Cole, F.G.S. 596

2. On the Marine Fauna of the Boulder Clay. By Joseph Wright, F.G.S. 598

3. Report on the Exploration of Irish Caves (p. 247) 598

4. *On the Middle Cambrian Trilobites, &c., of Mount Stephen, British Columbia. By Dr. Henry Woodward, F.R.S. 598

5. Preliminary List of the Minerals occurring in Ireland. By Henry J. Seymour, B.A. 598

6. *On the Tusks and Skull of *Mastodon angustidens*. By C. W. Andrews, D.Sc. 599

7. Report on the Registration of all Type Specimens of British Fossils (p. 210) 599

8. Notes on the Fossils of the Silurian Area of N.E. Ireland. By R. Clark 599

9. Note on the Occurrence of Bagshot Beds at Combe Pyne, near Lyme Regis. By Horace B. Woodward, F.R.S. 601

FRIDAY, SEPTEMBER 12.

1. On the Viscous Fusion of Rock-forming Minerals. By J. Joly, F.R.S. ... 602

2. *The Drift Map of the Dublin Area. By J. J. H. Teall, F.R.S. 602

3. Note on the Volcanic Rocks of Glencoe, and their Relation to the Granite of Ben Cruachan. By Herbert Kynaston 602

4. *Notes on the New Geological Map of Victoria. By James Stirling ... 603

5. On the Original Form of Sedimentary Deposits. By Rev. J. F. Blake, M.A., F.G.S. 603

6. Fossils from Cretaceous Strata in the Salt Range of India. By Professor H. G. Seeley, F.R.S., V.P.G.S. 604

7. *Investigations into the Glacial Drifts of the North-east of Ireland, conducted by the Belfast Naturalists' Field Club. By Madame Christen ... 604

Page

8. On the Brockrams of the Vale of Eden and the Evidence they afford of an inter-Permian Movement of the Pennine Faults. By Percy F. Kendall, F.G.S. 604

9. Report on the Erratic Blocks of the British Isles (p. 252) 606

10. The Conditions under which Manganese Dioxide has been Deposited in Sedimentary Rocks, as illustrated by the Elgin Sandstones. By William Mackie, M.A., M.D. 606

11. The so-called 'Fossil' Water of Sedimentary Strata, as illustrated by the Sandstones of the Moray Firth Basin. By William Mackie, M.A., M.D. 608

MONDAY, SEPTEMBER 15.

1. On the Structure of Ireland. By Professor Grenville A. J. Cole, F.G.S. 609

2. On the Fossil Fishes of the Lower Devonian Roofing-slate of Gemünden in Germany. By R. H. Traquair, M.D., F.R.S 610

3. On the Prolongation of the Highland Border Rock into Co. Tyrone. By G. Barrow 610

4. The Fossil Flora of the Cumberland Coalfield. By E. A. Newell Arber, M.A., F.G.S. 611

5. The Post-Glacial Deposits of the Belfast District. By R. Lloyd Praeger 611

TUESDAY, SEPTEMBER 16.

1. Report on the Movements of Underground Waters of North-west Yorkshire (p. 224) 612

2. Report on the Collection and Preservation of Photographs of Geological Interest (p. 229) 612

3. On the Valleys at the Head of the Hardanger Fjord, Norway. By Horace Woollaston Monckton, F.L.S., F.G.S. 612

4. The Evidence of the Hydrothermal Metamorphism of the Schists of South Devon. By A. R. Hunt, F.G.S. 613

5. Note on the Scenery of Ceylon. By A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S. 613

6. On some New Fossils from Penmorfa, and their Bearing on the Cambro-Ordovician Succession near Tremadoc. By W. G. Fearnsides, B.A., F.G.S. 614

7. Preliminary Note on a Carboniferous Fish Fauna from Victoria, Australia. By A. Smith Woodward, LL.D., F.R.S. 615

8. A Summary of the Principal Changes in South-east England during Pliocene and more Recent Times. By Horace Woollaston Monckton, F.L.S., F.G.S. 616

9 Report on Life-zones in the British Carboniferous Rocks (p. 210) 617

SECTION D.—ZOOLOGY.

THURSDAY, SEPTEMBER 11.

Page
Address by Professor G. B. Howes, D.Sc., LL.D., F.R.S., President of the Section 618
1. On British Fisheries' Investigations and the International Scheme. By Professor W. C. McIntosh, F.R.S. 638
2. *The International Investigation of the North Sea. By Walter Garstang, M.A. 641
3. Certain Objections to the Proposed Scheme of International Investigations of the North Sea. By D. Noël Paton, M.D., B.Sc. 641
4. The Scales of Fishes as an Index of Age. By J. Stuart Thomson 642
5. Report on the Migration of Birds (p. 273) 642
6. Report on the Occupation of a Table at the Zoological Station at Naples (p. 259) 642
7. Report on Investigations made at the Marine Biological Laboratory, Plymouth (p. 271) 642
8. Report on the 'Index Animalium' (p. 283) 642
9. Twelfth Report on the Zoology of the Sandwich Islands (p. 284) 642
10. Third Report on the Coral Reefs of the Indian Region (p. 284) 643
11. Report on Investigations in the Laboratory of the Marine Biological Association of the West of Scotland at Millport (p. 271) 643

FRIDAY, SEPTEMBER 12.

1. *Account of his Recent Expedition to the Indian Ocean, including Work on the Pearl Oyster Banks of the Gulf of Manaar. By Professor W. A. Herdman, F.R.S. 643
2. On the Amphipods collected by Professor Herdman. By A. O. Walker, F.L.S. 643
3. On the Plankton of the Indian Ocean. By Isaac C. Thompson, F.L.S. 643
4. *On the Cuttlefishes collected by Professor Herdman. By W. E. Hoyle, M.A. 644
5. On Deposits dredged by Professor Herdman in the Indian Ocean. By J. Lomas, A.R.C.S., F.G.S. 644
6. Notice of a hitherto unrecorded Element in the Occipital Bone of Seals. By Professor Cleland, F.R.S. 646
7. *On the Habits of the Predaceous Flies of the Family of Asilidæ. By Professor E. B. Poulton, F.R.S. 647
8. The Development of the Common Sea-urchin (*Echinus esculentus*). By Professor E. W. MacBride, D.Sc. 647
9. *The Relationships of the Larva to the Adult in the Starfish. By Dr. A. T. Masterman 647
10. On the Cause of Salmon Disease. By J. Hume Patterson 647

MONDAY, SEPTEMBER 15.

Page

1. *The Segmentation and Early Developmental Stages of the Australian Native Cat (*Dasyurus*). By Professor G. B. Howes, F.R.S. 649
2. *Recent Intercrossing Experiments with Dogs. By Professor J. C. Ewart, F.R.S. 649
3. *Flower-like Insects from the Malay Peninsula. By Nelson Annandale 649
4. *On Protective Resemblance in the Malay Peninsula. By H. C. Robinson 650
5. *Exhibition by Professor E. B. Poulton, F.R.S., of (1) Lantern Illustrations of British Insects in their natural attitudes. (2) Three-colour Lantern Slides of Mimicry, Protective Resemblance, Seasonal Forms of Butterflies, &c., and Discussion on 'The Interpretation of such Phenomena by the Theory of Natural Selection,' opened by Professor Poulton 650
6. Examples of Australian Fauna. By Thomas Steel, F.L.S. 650
7. Notes on a Specimen of the Pilot Whale (*Globiocephalus melas*). By Professor R. J. Anderson, M.D. 650
8. The Connection of the Anterior Inferior Angle of the Parietal Bone in Primates. By Professor R. J. Anderson, M.D. 651
9. Notes on the Habits of the Onuphididæ (Polychæta) and on the Internal Structures with which they Fortify their Homes. By Arnold T. Watson, F.L.S. 652
10. On an Acœlous Turbellarian inhabiting the common Heart Urchin. By R. T. Leiper 652

TUESDAY, SEPTEMBER 16.

1. Some Remarks on the Atlantis Problem. By R. F. Scharff, Ph.D....... 653
2. Diagram of the Skull of *Mastodon angustidens.* By Dr. C. W. Andrews, B.A., F.G.S., F.Z.S. 654
3. The Breaking-up of Coral Rock by Organisms in the Tropics. By J. Stanley Gardiner, M.A. 654
4. The Early Development of Muscles and Motor Nerves in *Lepidosiren.* By Professor J. Graham Kerr 655
5. *The Development of *Xenopus* (*Dactylethra*). By E. J. Bles, B.Sc. 657
6. *Experiments on the Axolotl: Adaptations to Life in an Alkaline Medium. By E. J. Bles, B.Sc. 657
7. On the Insect Fauna of some Irish Caves. By George H. Carpenter, B.Sc. 657
8. *On the Significance of the Embryonic Cell. By Professor C. S. Minot... 658
9. The Bird Fauna of Ireland as affected by its Geography. By R. J. Ussher 658
10. On the Structure of the Scales in the Cod. By H. W. Marett Tims, B.A., M.D. 660

WEDNESDAY, SEPTEMBER 17.

*Discussion upon Mimicry and Natural Selection. Opened by Professor E. B. Poulton, F.R.S. 661

*Some Remarks on Early Development of the Head-kidney in Polygordius and Eupomatus. By C. Shearer............... 661

SECTION E.—GEOGRAPHY.

THURSDAY, SEPTEMBER 11.

Page
Address by Colonel Sir T. H. HOLDICH, C.B., K.C.I.E., F.R.G.S., President of the Section 662
1. The Geography of Southern Persia as affecting its History, together with a Brief Account of the Helmand Delta and the Great Desert of Persia known as the Lut. By Major P. MOLESWORTH SYKES, C.M.G. 677

FRIDAY, SEPTEMBER 12.

1. Yünnan. By Captain C. H. D. RYDER, R.E. 678
2. Colonisation and Irrigation in Uganda and the British East Africa Protectorate. By R. B. BUCKLEY, C.S.I. 679
3. Survey of the Fresh-water Lakes of the British Isles. By T. N. JOHNSTON, M.B., C.M. 680
4. The Jordan Valley. By Professor WILLIAM LIBBEY, Sc.D. 680
5. Petra. By Professor WILLIAM LIBBEY, Sc.D. 681

MONDAY, SEPTEMBER 15.

1. World-shaking Earthquakes in relation to Volcanic Eruptions in the West Indies. By JOHN MILNE, F.R.S. 682
2. *Preliminary Note on the Windings of the Evenlode. By Dr. A. J. HERBERTSON 683
3. Geographical Plant-groups in the Irish Flora. By R. LLOYD PRAEGER, B.E. 683
4. On some Features of the Cork River-valleys. By J. PORTER 684
5. The Peat-bogs of Ireland. By Professor T. JOHNSON, D.Sc. 684
6. The Island of Sakhalin and its Inhabitants. By C. H. HAWES, B.A. 684

TUESDAY, SEPTEMBER 16.

1. The Motives of Antarctic Exploration. By HUGH ROBERT MILL, D.Sc., LL.D. 685
2. The Scottish National Antarctic Expedition. By W. S. BRUCE 686
3. The Islet of Rockall. By Rev. W. SPOTSWOOD GREEN, F.R.G.S. 686
4. *Charnwood Forest, a Buried Triassic Landscape. By Professor W. W. WATTS, F.G.S. 687
5. Second Report on Terrestrial Surface Waves and Wave-like Surfaces (p. 285) 687
6. *Note on Captain Sverdrup's North Polar Expedition. By Sir CLEMENTS MARKHAM, K.C.B., F.R.S. 687
7. *With Lieutenant Peary in Greenland. By Professor WILLIAM LIBBEY, Sc.D. 687

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

THURSDAY, SEPTEMBER 11.

Page
Address by EDWIN CANNAN, M.A., LL.D., President of the Section 688
1. The Localisation of Industry. By Rev. W. CUNNINGHAM, D.D. 695
2. The Influence of Economic History on Economic Theory. By ARCH. B. CLARK, M.A. 695
3. The Position of Economics and the Applied Sciences in a proposed University Training of Persons intended for a Commercial Life. By W. R. SCOTT, M.A., D.Phil., Litt.D. 696

FRIDAY, SEPTEMBER 12.

1. Trusts: from the Point of View of Economical Theory. By Professor W. GRAHAM, M.A. 697
2. Shipping Combinations. By BENEDICT WILLIAM GINSBURG, M.A., LL.D. 698
3. Municipal Trading. By Hon. ROBERT P. PORTER 699
4. Municipal Policy and State Control. By PERCY ASHLEY, B.A. 700

MONDAY, SEPTEMBER 15.

1. A Sketch of the Linen Industry of Ireland. By Sir R. LLOYD PATTERSON, D.L., F.L.S. 701
2. A British Zollverein, or Preferential Tariffs within the British Empire. By His Honour Judge SHAW, K.C. 702
3. The Effects on Ireland of the Adoption of Free Trade by the United Kingdom. By BENJAMIN ALLEN, M.A. 703
4. The Instability of Prices in India before 1861. By Professor T. MORISON, M.A. 704
5. The Depopulation of Ireland: its Causes and Economic Results. By J. H. EDGAR, M.A. 705
6. The Population of England and Wales during the Eighteenth Century. By Professor E. C. K. GONNER, M.A. 706

TUESDAY, SEPTEMBER 16.

1. Report on the Economic Effect of Legislation regulating Women's Labour (p. 286) 706
2. History of the Regulation of Home Work, 1864–1901. By Miss B. L. HUTCHINS 706
3. The Administration of the Factory and Workshops Acts by Local Sanitary Authorities. By Miss A. HARRISON 707
4. Nature's Economics. By Miss HELEN BLACKBURN 708
5. The Regulation of Wages in Developed Industries. By Professor S. J. CHAPMAN, M.A. 708
6. Some Urgent Needs of a Great City. By Miss L. A. WALKINGTON 709
7. The Increase in Consumption in Ireland. By ROBERT BROWN 709

SECTION G.—ENGINEERING.

THURSDAY, SEPTEMBER 11.

Page
Address by Professor JOHN PERRY, D.Sc., F.R.S., President of the Section ... 711
1. Recent Progress in Large Gas Engines. By HERBERT A. HUMPHREY, A.M.Inst.C.E. ... 729

FRIDAY, SEPTEMBER 12.

1. *Steam Turbines. By Hon. C. A. PARSONS, F.R.S. ... 730
2. Report on the Resistance of Road Vehicles to Traction (p. 314) ... 730
3. On Regular Undulations produced in a Road by the Use of Sledges. By VAUGHAN CORNISH, D.Sc., F.G.S., F.C.S., F.R.G.S. ... 730
4. A New Elastic Vehicle Wheel. By J. BROWN, F.R.S. ... 731
5. An All-stations Express Train. By J. BROWN, F.R.S. ... 732
6. The Rainfall of Ireland. By HUGH ROBERT MILL, D.Sc., LL.D., F.R.S.E. 732
7. *Water Power in Ireland. By F. J. DICK ... 733
8. A Direct Reducing Levelling Staff. By G. W. HERDMAN, B.Sc. ... 733

MONDAY, SEPTEMBER 15.

1. *The Future of the Telephone in the United Kingdom. By J. E. KINGSBURY ... 734
2. *A New Magnetic Testing Instrument. By F. HOLDEN ... 734
3. The Electrical Conductivity of certain Aluminium Alloys as affected by Exposure to London Atmosphere. By Professor ERNEST WILSON ... 734
4. Some Electrical Instruments. By M. B. FIELD ... 734
5. *The Science of the Workshop. By W. TAYLOR ... 735
6. *The Importance of Minor Details in Engineering Work. By M. HOLROYD SMITH ... 725
7. *On the Specific Utilisation of Materials in Dynamo Construction. By Professor S. P. THOMPSON, F.R.S. ... 735
8. *A New Flashing Lighthouse Light without Intervals of Darkness. By J. R. WIGHAM ... 735
9. *A Joint Discussion with Section L on the Training of Engineers ... 735

TUESDAY, SEPTEMBER 16.

1. Report on the Small Screw Gauge (p. 350) ... 735
2. The Smokeless Combustion of Bituminous Fuel. By W. H. BOOTH, M.Am.Soc.C.E. ... 736
3. *The Prevention of Smoke. By J. S. RAYWORTH ... 736
4. *The Solignac Boiler. By W. H. BOOTH ... 736
5. *The Making of a Dynamo. By H. A. MAVOR ... 736
6. *Experiences with the Infantry Range-finder in the South African War. By Professor G. FORBES, F.R.S. ... 736

Page
7. A Preliminary Note on Gas-engine Explosions. By H. E. WIMPERIS ... 736
8. *A Note on Gas-engine Explosions. By Professor J. PERRY, F.R.S. 737
9. The Direction and Velocity of Material-bearing Ocean Currents, with Description of an Apparatus recently designed for Estimating the same. By R. G. ALLANSON-WINN, B.A., M.Inst.C.E.I. 737

SECTION H.—ANTHROPOLOGY.

THURSDAY, SEPTEMBER 11.

Address by A. C. HADDON, M.A., Sc.D., F.R.S., M.R.I.A., President of the Section 738
1. The Initiation Ceremonies of the Natives of the Papuan Gulf. By Rev. J. H. HOLMES 752
2. The Religious Ideas, Totems, Spirits, and Gods of Elema. By Rev. J. H. HOLMES 752
3. Human Souls and Ghosts among the Malays of Patani. By NELSON ANNANDALE 752
4. *Cornelius Magrath, the Irish Giant. By Professor D. J. CUNNINGHAM, M.D., F.R.S. 753
5. *On a Skull modified by Acromegaly. By Professor A. F. DIXON, M.B. 753
6. *Exhibition of Specimens illustrating Physical Anthropology. By Professor J. SYMINGTON, M.D., F.R.S.E. 753
7. On some Ulster Souterrains. By WILLIAM J. FENNELL 753
8. On some Ancient Subterranean Chambers recently discovered at Waddon, near Croydon. By GEORGE CLINCH, F.G.S. 754
9. Underground Dwellings in the British Isles. By DAVID MACRITCHIE, F.S.A.Scot. 755

FRIDAY, SEPTEMBER 12.

1. The Oldest Bronze-Age Ceramic Type in Britain: its Close Analogies on the Rhine; its Probable Origin in Central Europe. By the Hon. JOHN ABERCROMBY 755
2. On Objects of the Plateau Kind from the Interglacial Gravels of Ireland. By W. J. KNOWLES 756
3. On Stone Axe Factories near Cushendall, Co. Antrim. By W. J. KNOWLES 757
4. The Manufacture of Arrow- and Spear-heads. By W. J. KNOWLES 758
5. On a recent Discovery of Palæolithic Implements in Plateau Gravels of Ipswich. By Miss NINA F. LAYARD 759
6. On a recent Find of Palæolithic Flint Implements at Knowle, Wiltshire. By WM. CUNNINGTON, F.G.S., and WM. A. CUNNINGTON, Ph.D. 759
7. Notes on the Excavation of a Primitive Site near Groomsport, Co. Down. By ROBERT M. YOUNG 759
8. On the Occurrence in Ireland of Objects of Hallstatt Types. By G. COFFEY 760
9. Report on Explorations in Crete (p. 466).. 760

MONDAY, SEPTEMBER 15.

Page

1. Report on Anthropometric Investigations among the Native Troops of the Egyptian Army (p. 350) 760
2. *Note on a Method of Radial Craniometry. By C. S. MYERS, M.D. 760
3. Measurements of the Indian Coronation Contingent. By J. GRAY, B.Sc. 760
4. *Note on some Measurements of Eskimo of Southampton Island. By J. F. TOCHER, F.I.C. 762
5. Report on the Pigmentation Survey of the School Children of Scotland (p. 352) 762
6. On the Mental and Moral Characteristics of the People of Ulster. By WILLIAM GRAHAM, M.D. 762
7. A Study in the Psychology of Primitive Man. By A. AMY BULLEY...... 764
8. On the Lolos and other Tribes of Western China. By AUGUSTINE HENRY 765
9. On the Wild and Civilised Races of the Malay Peninsula. By NELSON ANNANDALE and H. C. ROBINSON 766

TUESDAY, SEPTEMBER 16.

1. The Lia Fáil of Tara, and Election of Kings by Augury. By E. SIDNEY HARTLAND 766
2. On Perforated Stone Amulets. By F. T. ELWORTHY, F.S.A. 767
3. Note on Two Japanese 'Bokŭ-to.' By E. S. HARTLAND 767
4. On Tallies. By E. LOVETT 767
5. Report on the Age of Stone Circles (p. 455) 768
6. Preliminary Note on a Prehistoric Cemetery-cave in Palestine. By R. A. STEWART MACALISTER, M.A. 768
7. On a Survival of certain Pagan Sepulchral Symbols on Early Christian Monuments in Ireland. By P. J. O'REILLY 769
8. Report on the Excavations in the Roman Fort at Gellygaer (p. 450) 769
9. Report on the Excavations of the Roman City at Silchester (p. 453) 769
10. On the Khami Ruins, near Bulawayo, Rhodesia. By F. P. MENNELL, F.G.S., Curator of the Rhodesia Museum 769
11. *On the Ethnography of the Nagas. By W. H. FURNESS, M.D. 770
12. *Demonstration on the Specimens in the Anatomical Museum which illustrate points in Physical Anthropology. By Professor J. SYMINGTON, M.D. 770

WEDNESDAY, SEPTEMBER 17.

1. *Excavations at Palæokastro in Eastern Crete. By R. C. BOSANQUET, M.A. 770
2. Report on the Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest (p. 449) 770
3. Report on the Organisation of an Ethnological Survey of Canada (p. 353) 770
4. *On the Classification and Arrangement of the Exhibits in an Anthropological Museum. By W. H. HOLMES 770
5. *Suggestions for the Classification of the Subject-matter of Anthropology. By E. N. FALLAIZE, B.A. 770

SECTION I.—PHYSIOLOGY.

THURSDAY, SEPTEMBER 11.

Page

Address by Professor W. D. HALLIBURTON, M.D., F.R.S., President of the Section ... 771

1. *The Hydrolysis of Glycogen. By W. A. OSBORNE, D.Sc., and S. ZOBEL 780

2. *On the Innervation and Movements of the Stomach. By W. PAGE MAY, M D. ... 780

3. *The Functions of the Rods and Cones of the Retina. By F. W. EDRIDGE-GREEN, M.D. ... 780

FRIDAY, SEPTEMBER 12.

1. *On the Diuretic Action of Pituitary Extracts. By Professor E. A. SCHÄFER, F.R.S. ... 780

2. On the Relative Effects of Section of the Pyramidal Tracts and Anterior Columns in the Monkey. By Professor E. A. SCHÄFER, F.R.S. ... 780

3. *A Case of Paralysis of Convergence. By CYRIL SHAW, M D. ... 781

4. *Determination of the Least Perceptible Tone-difference among the People of the Torres Straits and of Scotland. By C. S. MYERS, M.A., M.D. ... 781

5. Some new Features in the Intimate Structure of the Human Cerebral Cortex. By JOHN TURNER, M.B. ... 781

6. *The Nervous System of the Camel. By W. PAGE MAY, M.D. ... 782

7. Regeneration of Nerves. By W. D. HALLIBURTON, M.D., F.R.S., and F. W. MOTT, M.D., F.R.S. ... 782

MONDAY, SEPTEMBER 15.

1. *The Estimation of Urea in Physiological Fluids. By J. BARCROFT, M.A., B.Sc. ... 784

2. *Demonstration of Edinger's Apparatus for Higher Magnifications and Stronger Light. By Professor SYMINGTON, M.D., and CECIL SHAW, M.D. ... 784

3. *The Pigments of Ox Bile. By W. A. OSBORNE, D.Sc. ... 784

4. *The Indefatigability of Medullated Nerve. By Professor F. GOTCH, F.R.S. ... 784

5. Report on the Work of the Mammalian Heart (p. 470) ... 784

6. Report on the Micro-Chemistry of Cells (p. 470) ... 784

SECTION K.—BOTANY.

THURSDAY, SEPTEMBER 11.

Address by Professor J. REYNOLDS GREEN, M.A., Sc.D., F.R.S., President of the Section ... 785

1. *Exhibition of Form of *Erica tetralix* from Connemara. By Professor I. BAYLEY BALFOUR, F.R.S. ... 799

Page
2. Notes on a Census of the Flora of the Australian Alps. (Part I.) By JAMES STIRLING 799
3. On Luminous Bacteria. By J. E. BARNARD and Professor ALLAN MACFADYEN, M.D. 801
4. Report on the Respiration of Plants (p. 472) 802
5. Report on the Cyanophyceæ (p. 473) 802
6. Report on the Collection and Preservation of Botanical Photographs (p. 471) 802
7. *Exhibition of some Characteristic Australian Plants. By THOMAS STEEL 802

FRIDAY, SEPTEMBER 12.

1. Electric Response of Ordinary Plants under Mechanical Stimulus. By Professor JAGADIS CHUNDER BOSE, M.A., D.Sc. 802
2. The Movements of the Flower-buds of *Sparmannia africana*. By RINA SCOTT 803
3. *On the Germination of Fatty Seeds. By Professor J. REYNOLDS GREEN, F.R.S., and H. JACKSON 804
4. On the Suspension of Life at Low Temperatures. By ALLAN MACFADYEN, M.D., and SYDNEY ROWLAND, M.A. 804
5. Resistance of Seeds to High Temperatures. By HENRY H. DIXON, D.Sc. 805
6. The Effect of Temperature on Carbon Dioxide Assimilation. By Miss GABRIELLE L. C. MATTHAEI 805
7. On the Dorsiventrality of the Podostemaceæ, with reference to current views on Evolution. By JOHN C. WILLIS 806
8. Foliar Periodicity in Ceylon. By HERBERT WRIGHT 807

MONDAY, SEPTEMBER 15.

1. *Fossil *Nipa* Fruits from Belgium. By A. C. SEWARD, M.A., F.R.S., and E. N. ARBER, M.A. 808
2. The Seed-like Fructification of *Miadesmia membranacea* (Bertrand), a Lycopodiaceous Plant from the Coal Measures. By MARGARET BENSON, D.Sc. 808
3. A possible Calymmatotheca Type of Fructification showing Structure. By MARGARET BENSON, D.Sc. 808
4. On some New Features in relation to *Lyginodendron oldhamium*. By J. LOMAX 809
5. Sporangiophores as a Clue to Affinities among Pteridophyta. By D. H. SCOTT, M.A., Ph.D., F.R.S. 810
6. Notes on the Morphology of the Araucarieæ. By SIBILLE O. FORD 810
7. On the Occurrence of the Nodular Concretions (Coal Balls) in the Lower Coal Measures. By JAMES LOMAX 811
8. The Morphology of Sporangial Integuments. By W. C. WORSDELL 812
9. *On Ancient and Modern Seeds. By Professor F. W. OLIVER, D.Sc. 813

TUESDAY, SEPTEMBER 16.

Page

1. On the Morphology of the Seed and Seedling of *Torreya*. By Professor F. W. OLIVER, D.Sc., and Miss EDITH CHICK 814
2. The Nature of the Vascular System of the Stem in certain Dicotyledonous Orders. By W. C. WORSDELL 814
3. The Composition of the Flora of the North-east of Ireland. By R. LLOYD PRAEGER 815
4. *The Nucleus of the Cyanophyceæ. By HAROLD WAGER 816

WEDNESDAY, SEPTEMBER 17.

1. A Disease of the Gooseberry, with Notes on *Botrytis* and *Sclerotium*. By Miss ANNIE LORRAIN SMITH 816
2. On the Morphology of the Flowers in certain species of *Lonicera*. By E. A. NEWELL ARBER, M.A., F.G.S. 816
3. Some Inquiry into the Physics of the Flow of Fluids in Plant Stems. By Professor R. J. ANDERSON, M.D., F.L.S. 817
4. *The Function of the Nucleolus. By HAROLD WAGER, F.L.S. 818
5. Samsu, a Fermented Drink of Eastern Asia, and its Characteristic Fungus. By B. T. P. BARKER 818
6. *The Darnel Seed-fungus. By E. M. FREEMAN 819
7. Sex in Ceylon Species of *Diospyros*. By HERBERT WRIGHT 819
8. *Weisia rostellata*, Lindb., in Ireland. By J. H. DAVIES 819
9. *Two Varieties of *Trifolium pratense perenne*. By W. WILSON 819

SECTION L.—EDUCATIONAL SCIENCE.

THURSDAY, SEPTEMBER 11.

Address by Professor HENRY E. ARMSTRONG, LL.D., Ph.D., V.P.R.S., President of the Section 820

1. Report on the Teaching of Elementary Mathematics (p. 473) 844
2. *On Recent Reforms in Irish Education. By Dr. W. J. M. STARKIE ... 844
3. The Subjects to be taught as Science in Schools, and the Order in which they should be taken. By Dr. C. W. KIMMINS 844

FRIDAY, SEPTEMBER 12.

1. The Introduction of Practical Instruction into Irish National Schools. By W. MAYHOWE HELLER 845
2. *Intermediate Education in Ireland. By R. M. JONES, M.A. 846
3. *Intermediate Education in Ireland. By Rev. Father MURPHY 846
4. *The Relation of Technical Instruction to Industrial Development in Ireland. By T. P. GILL 847

MONDAY, SEPTEMBER 15.

Page

1. Report on the Conditions of Health Essential to the carrying-on of the Work of Instruction in Schools (p. 483).. 847
2. Report on the Teaching of Science in Elementary Schools (p. 481) 847
3. *Discussion on the Training of Teachers. Opened by Miss L. EDNA WALTER and Professor H. L. WITHERS 847
4. *Joint Discussion with Section G on the Training of Engineers 847

TUESDAY, SEPTEMBER 16.

1. *A Universal Language. By Sir F. J. BRAMWELL, Bart., F.R.S. 847
2. *Discussion on the Teaching of English. Opened by P. J. HARTOG, B.Sc. 847
3. The Neglect of English Grammar. By Professor MINCHIN................. 847
4. *Joint Discussion with Section A on the Teaching of Mathematics......... 848
5. On the Teaching of Elementary Mathematics. By A. W. SIDDONS, M.A. 848

APPENDIX.

Corresponding Societies Committee.—Report of the Committee, consisting of Mr. W. WHITAKER (Chairman), Dr. J. G. GARSON (Secretary), Professor MELDOLA, Mr. FRANCIS GALTON, Sir JOHN EVANS, Mr. J. HOPKINSON, Professor BONNEY, Mr. T. V. HOLMES, Dr. HORACE T. BROWN, Rev. J. O. BEVAN, Professor W. W. WATTS, REV. T. R. R. STEBBING, Mr. C. H. READ, and Mr. F. W. RUDLER. (Drawn up by the Secretary) 851

Report of the Conference of Delegates of Corresponding Societies held at Belfast, September 1902 856
- Address by the Chairman, Professor W. W. WATTS, M.A., M.Sc., Sec. G.S. 858
- A Plea for a Pigmentation Survey of School Children in Ireland. By J. F. TOCHER 865
- A Plea for an Ordnance Map Index of Prehistoric Remains. By CHARLES H. READ, F.S.A. 870

ERRATA.

The Movements of Underground Waters of North-west Yorkshire:

Page 225, line 16, *for* 1,225 *read* 825.
" " " 17 " 1,200 " 800.

LIST OF PLATES.

PLATE I.

Illustrating the Report on Seismological Investigation.

PLATE II.

Illustrating the Report on the Movements of Underground Waters of North-west Yorkshire.

PLATES III.–VII.

Illustrating the Report on the Resistance of Road Vehicles to Traction.

OBJECTS AND RULES

OF

THE ASSOCIATION.

OBJECTS.

The Association contemplates no interference with the ground occupied by other institutions. Its objects are:—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

Admission of Members and Associates.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

Compositions, Subscriptions, and Privileges.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*; but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the offices of the Association.

ASSOCIATES for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.
2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.
3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]
4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]
5. Associates for the year, subject to the payment of One Pound.
6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members *who have not intermitted* their Annual Subscription.
2. *At reduced or Members' Price*, viz., two-thirds of the Publication Price. —Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]
3. Members may purchase (for the purpose of completing their sets) any of the volumes of the Reports of the Association up to 1874, *of which more than* 15 *copies remain*, at 2*s.* 6*d.* per volume.[1]

Application to be made at the Office of the Association.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

Subscriptions shall be received by the Treasurer or Secretaries.

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[1] A few complete sets, 1831 to 1874, are on sale at £10 the set.

Meetings.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee not less than two years in advance[1]; and the arrangements for it shall be entrusted to the Officers of the Association.

General Committee.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

CLASS A. PERMANENT MEMBERS.

1. Members of the Council, Presidents of the Association, and Presidents of Sections for the present and preceding years, with Authors of Reports in the Transactions of the Association.

2. Members who by the publication of Works or Papers have furthered the advancement of those subjects which are taken into consideration at the Sectional Meetings of the Association. *With a view of submitting new claims under this Rule to the decision of the Council, they must be sent to the Assistant General Secretary at least one month before the Meeting of the Association. The decision of the Council on the claims of any Member of the Association to be placed on the list of the General Committee to be final.*

CLASS B. TEMPORARY MEMBERS.[2]

1. Delegates nominated by the Corresponding Societies under the conditions hereinafter explained. *Claims under this Rule to be sent to the Assistant General Secretary before the opening of the Meeting.*

2. Office-bearers for the time being, or delegates, altogether not exceeding three, from Scientific Institutions established in the place of Meeting. *Claims under this Rule to be approved by the Local Secretaries before the opening of the Meeting.*

3. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing, for the Meeting of the year, by the President and General Secretaries.

4. Vice-Presidents and Secretaries of Sections.

Organising Sectional Committees.[3]

The Presidents, Vice-Presidents, and Secretaries of the several Sections are nominated by the Council, and have power to exercise the functions of Sectional Committees until their names are submitted to the General Committee for election.

From the time of their nomination they constitute Organising Committees for the purpose of obtaining information upon the Memoirs and Reports likely to be submitted to the Sections,[4] and of preparing Reports thereon, and on the order in which it is desirable that they should be read. The Sectional Presidents of former years are *ex officio* members of the Organising Sectional Committees.[1]

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[1] Revised by the General Committee, Liverpool, 1896.

[2] Revised, Montreal, 1884.

[3] Passed, Edinburgh, 1871, revised, Dover, 1899.

[4] *Notice to Contributors of Memoirs.*—Authors are reminded that, under an arrangement dating from 1871, the acceptance of Memoirs, and the days on which

An Organising Committee may also hold such preliminary meetings as the President of the Committee thinks expedient, but shall, under any circumstances, meet on the first Wednesday of the Annual Meeting, at 2 P.M., to appoint members of the Sectional Committee.[2]

Constitution of the Sectional Committees.[3]

On the first day of the Annual Meeting, the President, Vice-Presidents, and Secretaries of each Section, who will be appointed by the General Committee at 4 P.M., and those previous Presidents and Vice-Presidents of the Section who may desire to attend, are to meet, at 2 P.M., in their Committee Rooms, and appoint the Sectional Committees by selecting individuals from among the Members (not Associates) present at the Meeting whose assistance they may particularly desire. Any Member who has intimated the intention of attending the Meeting, and who has already served upon a Committee of a Section, is eligible for election as a Member of the Committee of that Section at its first meeting.[4] The Sectional Committees thus constituted shall have power to add to their number from day to day.

The List thus formed is to be entered daily in the Sectional Minute-Book, and a copy forwarded without delay to the Printer, who is charged with publishing the same before 8 A.M. on the next day in the Journal of the Sectional Proceedings.

Business of the Sectional Committees.

Committee Meetings are to be held on the Wednesday, and on the following Thursday, Friday, Saturday,[5] Monday, and Tuesday, for the objects stated in the Rules of the Association. The Organising Committee of a Section is empowered to arrange the hours of meeting of the Section and the Sectional Committee except for Saturday.[6]

The business is to be conducted in the following manner:—

1. The President shall call on the Secretary to read the minutes of the previous Meeting of the Committee.

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they are to be read, are now as far as possible determined by Organising Committees for the several Sections *before the beginning of the Meeting*. It has therefore become necessary, in order to give an opportunity to the Committees of doing justice to the several Communications, that each author should prepare an Abstract of his Memoir of a length suitable for insertion in the published Transactions of the Association, and that he should send it, together with the original Memoir, by book-post, on or before........................., addressed to the General Secretaries, at the office of the Association. 'For Section.........' If it should be inconvenient to the Author that his paper should be read on any particular days, he is requested to send information thereof to the Secretaries in a separate note. Authors who send in their MSS. three complete weeks before the Meeting, and whose papers are accepted, will be furnished, before the Meeting, with printed copies of their Reports and abstracts. No Report, Paper, or Abstract can be inserted in the Annual Volume unless it is handed either to the Recorder of the Section or to the Assistant General Secretary *before the conclusion of the Meeting*.

[1] Sheffield, 1879. [2] Swansea, 1880, revised, Dover, 1899.

[3] Edinburgh, 1871, revised, Dover, 1899. [4] Glasgow, 1901.

[5] The meeting on Saturday is optional, Southport, 1883. [6] Nottingham, 1893.

2. No paper shall be read until it has been formally accepted by the Committee of the Section, and entered on the minutes accordingly.
3. Papers which have been reported on unfavourably by the Organising Committees shall not be brought before the Sectional Committees.[1]

At the first meeting, one of the Secretaries will read the Minutes of last year's proceedings, as recorded in the Minute-Book, and the Synopsis of Recommendations adopted at the last Meeting of the Association and printed in the last volume of the Report. He will next proceed to read the Report of the Organising Committee.[2] The list of Communications to be read on Thursday shall be then arranged, and the general distribution of business throughout the week shall be provisionally appointed.[2] At the close of the Committee Meeting the Secretaries shall forward to the Printer a List of the Papers appointed to be read. The Printer is charged with publishing the same before 8 A.M. on Thursday in the Journal.

On the second day of the Annual Meeting, and the following days, the Secretaries are to correct, on a copy of the Journal, the list of papers which have been read on that day, to add to it a list of those appointed to be read on the next day, and to send this copy of the Journal as early in the day as possible to the Printer, who is charged with printing the same before 8 A.M. next morning in the Journal. It is necessary that one of the Secretaries of each Section (generally the Recorder) should call at the Printing Office and revise the proof each evening.

Minutes of the proceedings of every Committee are to be entered daily in the Minute-Book, which should be confirmed at the next meeting of the Committee.

Lists of the Reports and Memoirs read in the Sections are to be entered in the Minute-Book daily, which, with all Memoirs and Copies or Abstracts of Memoirs furnished by Authors, are to be forwarded, at the close of the Sectional Meetings, to the Assistant General Secretary.

The Vice-Presidents and Secretaries of Sections become *ex officio* temporary Members of the General Committee (*vide* p. xxxi), and will receive, on application to the Treasurer in the Reception Room, Tickets entitling them to attend its Meetings.

The Committees will take into consideration any suggestions which may be offered by their Members for the advancement of Science. They are specially requested to review the recommendations adopted at preceding Meetings, as published in the volumes of the Association, and the communications made to the Sections at this Meeting, for the purposes of selecting definite points of research to which individual or combined exertion may be usefully directed, and branches of knowledge on the state and progress of which Reports are wanted; to name individuals or Committees for the execution of such Reports or researches; and to state whether, and to what degree, these objects may be usefully advanced by the appropriation of the funds of the Association, by application to Government, Philosophical Institutions, or Local Authorities.

In case of appointment of Committees for special objects of Science, it is expedient that all Members of the Committee should be named, and one of them appointed to act as Chairman, who shall have notified personally or in writing his willingness to accept the office, the Chairman to have the responsibility of receiving and disbursing the grant (if any has been made) and securing the presentation of the report in due time; and, further, it is expedient that one of the members should be appointed to act as Secretary, for ensuring attention to business.

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[1] Plymouth, 1877.

[2] Edinburgh, 1871.

That it is desirable that the number of Members appointed to serve on a Committee should be as small as is consistent with its efficient working.

That a tabular list of the Committees appointed on the recommendation of each Section should be sent each year to the Recorders of the several Sections, to enable them to fill in the statement whether the several Committees appointed on the recommendation of their respective Sections had presented their reports.

That on the proposal to recommend the appointment of a Committee for a special object of science having been adopted by the Sectional Committee, the number of Members of such Committee be then fixed, but that the Members to serve on such Committee be nominated and selected by the Sectional Committee at a subsequent meeting.[1]

Committees have power to add to their number persons whose assistance they may require.

The recommendations adopted by the Committees of Sections are to be registered in the Forms furnished to their Secretaries, and one Copy of each is to be forwarded, without delay, to the Assistant General Secretary for presentation to the Committee of Recommendations. *Unless this be done, the Recommendations cannot receive the sanction of the Association.*

N.B.—Recommendations which may originate in any one of the Sections must first be sanctioned by the Committee of that Section before they can be referred to the Committee of Recommendations or confirmed by the General Committee.

Notices regarding Grants of Money.[2]

1. No Committee shall raise money in the name or under the auspices of the British Association without special permission from the General Committee to do so; and no money so raised shall be expended except in accordance with the Rules of the Association.
2. In grants of money to Committees the Association does not contemplate the payment of personal expenses to the Members.
3. Committees to which grants of money are entrusted by the Association for the prosecution of particular Researches in Science are appointed for one year only. If the work of a Committee cannot be completed in the year, and if the Sectional Committee desire the work to be continued, application for the reappointment of the Committee for another year must be made at the next meeting of the Association.
4. Each Committee is required to present a Report, whether final or interim, at the next meeting of the Association after their appointment or reappointment. Interim Reports must be submitted in writing, though not necessarily for publication.

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[1] Revised by the General Committee, Bath, 1888.

[2] Revised by the General Committee at Ipswich, 1895.

5. In each Committee the Chairman is the only person entitled to call on the Treasurer, Professor G. Carey Foster, F.R.S., for such portion of the sums granted as may from time to time be required.
6. Grants of money sanctioned at a meeting of the Association expire on June 30 following. The Treasurer is not authorised after that date to allow any claims on account of such grants.
7. The Chairman of a Committee must, before the meeting of the Association next following after the appointment or reappointment of the Committee, forward to the Treasurer a statement of the sums which have been received and expended, with vouchers. The Chairman must also return the balance of the grant, if any, which has been received and not spent; or, if further expenditure is contemplated, he must apply for leave to retain the balance.
8. When application is made for a Committee to be reappointed, and to retain the balance of a former grant which is in the hands of the Chairman, and also to receive a further grant, the amount of such further grant is to be estimated as being additional to, and not inclusive of, the balance proposed to be retained.
9. The Committees of the Sections shall ascertain whether a Report has been made by every Committee appointed at the previous Meeting to whom a sum of money has been granted, and shall report to the Committee of Recommendations in every case where no such report has been received.
10. Members and Committees who may be entrusted with sums of money for collecting specimens of any description are requested to reserve the specimens so obtained to be dealt with by authority of the Council.
11. Committees are requested to furnish a list of any apparatus which may have been purchased out of a grant made by the Association, and to state whether the apparatus will be useful for continuing the research in question, or for other scientific purposes.
12. All Instruments, Papers, Drawings, and other property of the Association are to be deposited at the Office of the Association when not employed in scientific inquiries for the Association.

Business of the Sections.

The Meeting Room of each Section is opened for conversation shortly before the meeting commences. *The Section Rooms and approaches thereto can be used for no notices, exhibitions, or other purposes than those of the Association.*

At the time appointed the Chair will be taken,[1] and the reading of communications, in the order previously made public, commenced.

Sections may, by the desire of the Committees, divide themselves into Departments, as often as the number and nature of the communications delivered in may render such divisions desirable.

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[1] The Organising Committee of a Section is empowered to arrange the hours of meeting of the Section and of the Sectional Committee, except for Saturday.

A Report presented to the Association, and read to the Section which originally called for it, may be read in another Section, at the request of the Officers of that Section, with the consent of the Author.

Duties of the Doorkeepers.

1. To remain constantly at the Doors of the Rooms to which they are appointed during the whole time for which they are engaged.
2. To require of every person desirous of entering the Rooms the exhibition of a Member's, Associate's, or Lady's Ticket, or Reporter's Ticket, signed by the Treasurer, or a Special Ticket signed by the Assistant General Secretary.
3. Persons unprovided with any of these Tickets can only be admitted to any particular Room by order of the Secretary in that Room.

No person is exempt from these Rules, except those Officers of the Association whose names are printed in the Official Programme, p. 1.

Duties of the Messengers.

To remain constantly at the Rooms to which they are appointed during the whole time for which they are engaged, except when employed on messages by one of the Officers directing these Rooms.

Committee of Recommendations.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

The *ex officio* members of the Committee of Recommendations are the President and Vice-Presidents of the Meeting, the General and Assistant-General Secretaries, the General Treasurer, the Trustees, and the Presidents of the Association in former years.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee unless previously recommended by the Committee of Recommendations.

All proposals for establishing new Sections, or altering the titles of Sections, or for any other change in the constitutional forms and fundamental rules of the Association, shall be referred to the Committee of Recommendations for a report.[1]

If the President of a Section is unable to attend a meeting of the Committee of Recommendations, the Sectional Committee shall be authorised to appoint a Vice-President, or, failing a Vice-President, some other member of the Committee, to attend in his place, due notice of the appointment being sent to the Assistant General Secretary.[2]

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[1] Passed by the General Committee at Birmingham, 1865.

[2] Passed by the General Committee at Leeds, 1890.

Corresponding Societies.[1]

1. Any Society is eligible to be placed on the List of Corresponding Societies of the Association which undertakes local scientific investigations, and publishes notices of the results.

2. Application may be made by any Society to be placed on the List of Corresponding Societies. Applications must be addressed to the Assistant General Secretary on or before the 1st of June preceding the Annual Meeting at which it is intended they should be considered, and must be accompanied by specimens of the publications of the results of the local scientific investigations recently undertaken by the Society.

3. A Corresponding Societies Committee shall be annually nominated by the Council and appointed by the General Committee for the purpose of considering these applications, as well as for that of keeping themselves generally informed of the annual work of the Corresponding Societies, and of superintending the preparation of a list of the papers published by them. This Committee shall make an annual report to the General Committee, and shall suggest such additions or changes in the List of Corresponding Societies as they may think desirable.

4. Every Corresponding Society shall return each year, on or before the 1st of June, to the Assistant General Secretary of the Association, a schedule, properly filled up, which will be issued by him, and which will contain a request for such particulars with regard to the Society as may be required for the information of the Corresponding Societies Committee.

5. There shall be inserted in the Annual Report of the Association a list, in an abbreviated form, of the papers published by the Corresponding Societies during the past twelve months which contain the results of the local scientific work conducted by them; those papers only being included which refer to subjects coming under the cognisance of one or other of the various Sections of the Association.

6. A Corresponding Society shall have the right to nominate any one of its members, who is also a Member of the Association, as its delegate to the Annual Meeting of the Association, who shall be for the time a Member of the General Committee.

Conference of Delegates of Corresponding Societies.

7. The Conference of Delegates of Corresponding Societies is empowered to send recommendations to the Committee of Recommendations for their consideration, and for report to the General Committee.

8. The Delegates of the various Corresponding Societies shall constitute a Conference, of which the Chairman, Vice-Chairmen, and Secretaries shall be annually nominated by the Council, and appointed by the General Committee, and of which the members of the Corresponding Societies Committee shall be *ex officio* members.

9. The Conference of Delegates shall be summoned by the Secretaries to hold one or more meetings during each Annual Meeting of the Association, and shall be empowered to invite any Member or Associate to take part in the meetings.

10. The Secretaries of each Section shall be instructed to transmit to

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[1] Passed by the General Committee, 1884.

the Secretaries of the Conference of Delegates copies of any recommendations forwarded by the Presidents of Sections to the Committee of Recommendations bearing upon matters in which the co-operation of Corresponding Societies is desired; and the Secretaries of the Conference of Delegates shall invite the authors of these recommendations to attend the meetings of the Conference and give verbal explanations of their objects and of the precise way in which they would desire to have them carried into effect.

11. It will be the duty of the Delegates to make themselves familiar with the purport of the several recommendations brought before the Conference, in order that they and others who take part in the meetings may be able to bring those recommendations clearly and favourably before their respective Societies. The Conference may also discuss propositions bearing on the promotion of more systematic observation and plans of operation, and of greater uniformity in the mode of publishing results.

Local Committees.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

Officers.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer shall be annually appointed by the General Committee.

Council.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

(1) The Council shall consist of[1]

1. The Trustees.
2. The past Presidents.
3. The President and Vice-Presidents for the time being.
4. The President and Vice-Presidents elect.
5. The past and present General Treasurers, General and Assistant General Secretaries.
6. The Local Treasurer and Secretaries for the ensuing Meeting.
7. Ordinary Members.

(2) The Ordinary Members shall be elected annually from the General Committee.

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[1] Passed by the General Committee at Belfast, 1874.

(3) There shall be not more than twenty-five Ordinary Members, of whom not more than twenty shall have served on the Council, as Ordinary Members, in the previous year.

(4) In order to carry out the foregoing rule, the following Ordinary Members of the outgoing Council shall at each annual election be ineligible for nomination:—1st, those who have served on the Council for the greatest number of consecutive years; and, 2nd, those who, being resident in or near London, have attended the fewest number of Meetings during the year—observing (as nearly as possible) the proportion of three by seniority to two by least attendance.

(5) The Council shall submit to the General Committee in their Annual Report the names of the Members of the General Committee whom they recommend for election as Members of Council.

(6) The Election shall take place at the same time as that of the Officers of the Association.

Papers and Communications.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

Accounts.

The Accounts of the Association shall be audited annually, by Auditors appointed by the General Committee.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., Esq., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S. L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, Esq., F.R.S., Astronomer Royal, &c. John Dalton, Esq., D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, Esq., M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, F.L.S., F.G.S. John Dalton, Esq., D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Esq., Pres. Royal Institution Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, Esq., F.L.S., &c. Wm. Hutton, Esq., F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	The Marquis of Northampton. The Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. The Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, Esq., M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.

The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount-Edgcumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, Esq., D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, Esq., M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, Esq., M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	The Earl of Listowel. Viscount Adare. Sir W. R. Hamilton, Pres. R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S. The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. The Rev. Professor Powell, F.R.S.	Henry Clark, Esq., M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. The Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. De la Beche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's	Matthew Moggridge, Esq. D. Nicol, Esq., M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. The Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews EDINBURGH, July 21, 1850.	The Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. The Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. The Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S., F.R.S.E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, Pres. R.S., M.R.I.A. Sir Henry T. De la Beche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, Esq., M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., Pres. Camb. Phil. Society HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Phil. Society William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, Esq., M.D., V.P. Hull Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S., F.R.S.E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S.	Joseph Dickinson, Esq., M.D., F.R.S. Thomas Inman, Esq., M.D.

SIR H. E. ROSCOE, M.P., D.C.L., LL.D., Ph.D., F.R.S., V.P.C.S. MANCHESTER, August 31, 1887.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S. The Right Hon. the Earl of Derby, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Rev. the Lord Bishop of Manchester, D.D. The Right Rev. the Bishop of Salford The Right Worshipful the Mayor of Manchester The Right Worshipful the Mayor of Salford The Vice-Chancellor of the Victoria University The Principal of the Owens College Sir William Roberts, B.A., M.D., F.R.S. Thomas Ashton, Esq., J.P., D.L. Oliver Heywood, Esq., J.P., D.L. James Prescott Joule, Esq., D.C.L., LL.D., F.R.S., F.R.S.E., F.C.S.	F. J. Faraday, Esq., F.L.S., F.S.S. Charles Hopkinson, Esq., B.Sc. Professor A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S. Professor A. H. Young, M.B., F.R.C.S.
SIR FREDERICK J. BRAMWELL, D.C.L., F.R.S., M.Inst.C.E. BATH, September 5, 1888.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somerset The Most Hon. the Marquess of Bath The Right Hon. and Right Rev. the Lord Bishop of Bath and Wells, D.D. The Right Rev. the Bishop of Clifton, D.D. The Right Worshipful the Mayor of Bath The Right Worshipful the Mayor of Bristol Sir F. A. Abel, C.B., D.C.L., F.R.S., V.P.C.S. The Venerable the Archdeacon of Bath, M.A. The Rev. Leonard Blomefield, M.A., F.L.S., F.G.S. Professor Michael Foster, M.A., M.D., LL.D., Sec. R.S., F.L.S., F.C.S. W. S. Gore-Langton, Esq., J.P., D.L. H. D. Skrine, Esq., J.P., D.L. E. R. Wodehouse, Esq., M.P. Colonel R. P. Laurie, C.B., M.P. Jerom Murch, Esq., J.P., D.L.	W. Pumphrey, Esq. J. L. Stothert, Esq., M.Inst.C.E. B. H. Watts, Esq.
PROFESSOR WILLIAM HENRY FLOWER, C.B., LL.D., F.R.S., F.R.C.S., Pres. Z.S., F.L.S., F.G.S., Director of the Natural History Departments of the British Museum NEWCASTLE-UPON-TYNE, September 11, 1889.	His Grace the Duke of Northumberland, K.G., D.C.L., LL.D., Lord-Lieutenant of Northumberland The Right Hon. the Earl of Durham, Lord-Lieutenant of Durham The Right Hon. the Earl of Ravensworth The Right Rev. the Lord Bishop of Newcastle, D.D. The Right Hon. Lord Armstrong, C.B., D.C.L., LL.D., F.R.S. The Right Hon. John Morley, M.P., LL.D. The Very Rev. the Warden of the University of Durham, D.D. The Right Worshipful the Mayor of Newcastle The Worshipful the Mayor of Gateshead Sir I. Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., M.Inst.C.E. Sir Charles Mark Palmer, Bart., M.P.	Professor P. Phillips Bedson, D.Sc., F.C.S. Professor J. Herman Merivale, M.A.
SIR FREDERICK AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., P.P.C.S., Hon.M.Inst.C.E. LEEDS, September 3, 1890.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S. The Most Hon. the Marquess of Ripon, K.G., G.C.S.I., C.I.E., F.R.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Sir Lyon Playfair, K.C.B., Ph.D., LL.D., M.P., F.R.S. The Right Hon. W. L. Jackson, M.P. The Mayor of Leeds Sir James Kitson, Bart., M.Inst.C.E. Sir Andrew Fairbairn, M.A.	J. Rawlinson Ford, Esq. Sydney Lupton, Esq., M.A. Professor L. C. Miall, F.L.S., F.G.S. Professor A. Smithells, B.Sc.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester Professor E. Hodgkinson, F.R.S., M.R.I.A., M.Inst.C.E. Joseph Whitworth, Esq., F.R.S., M.Inst.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, Esq., M.A. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. The Rev. J. Challis, M.A., F.R.S. G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. Hugh Taylor, Esq., Chairman of the Coal Trade Isaac Lowthian Bell, Esq., Mayor of Newcastle Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers Rev. Temple Chevallier, B.D., F.R.A.S. William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. BATH, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somersetshire The Most Noble the Marquis of Bath The Right Hon. Earl Nelson The Right Hon. Lord Portman The Very Rev. the Dean of Hereford The Venerable the Archdeacon of Bath W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. W. Sanders, Esq., F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford BIRMINGHAM, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. The Right Rev. the Lord Bishop of Worcester The Right Hon. C. B. Adderley, M.P. William Scholefield, Esq., M.P. F. Osler, Esq., F.R.S. J. T. Chance, Esq. The Rev. Charles Evans, M.A.	William Mathews, jun., Esq., M.A., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.

WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. NOTTINGHAM, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint Joseph Hooker, Esq., M.D., F.R.S., F.L.S. John Russell Hind, Esq., F.R.S., F.R.A.S. T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. DUNDEE, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh James D. Forbes, Esq., LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonard, University of St. Andrews	J. Henderson, jun., Esq. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.
JOSEPH DALTON HOOKER, Esq., M.D., D.C.L., F.R.S., F.L.S. NORWICH, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge Thomas Brightwell, Esq.	Dr. Donald Dalrymple. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. EXETER, August 18, 1869.	The Right Hon. the Earl of Devon The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, Esq., M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, Esq., M.A., LL.D., F.R.S., F.L.S.	Henry S. Ellis, Esq., F.R.A.S. John C. Bowring, Esq. The Rev. R. Kirwan.
PROFESSOR T. H. HUXLEY, LL.D., F.R.S. F.G.S. LIVERPOOL, September 14, 1870.	The Right Hon. the Earl of Derby, LL.D., F.R.S. Sir Philip de Malpas Grey Egerton, Bart., M.P. The Right Hon. W. E. Gladstone, D.C.L., M.P. S. R. Graves, Esq., M.P. Sir Joseph Whitworth, Bart., LL.D., D.C.L., F.R.S. James P. Joule, Esq., LL.D., D.C.L., F.R.S. Joseph Mayer, Esq., F.S.A., F.R.G.S.	Rev. W. Banister. Reginald Harrison, Esq. Rev. Henry H. Higgins, M.A. Rev. Dr. A. Hume, F.S.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR SIR WILLIAM THOMSON, M.A., LL.D., F.R.S., F.R.S.E. EDINBURGH, August 2, 1871.	His Grace the Duke of Buccleuch, K.G., D.C.L., F.R.S. The Right Hon. the Lord Provost of Edinburgh The Right Hon. John Inglis, LL.D., Lord Justice-General of Scotland Sir Alexander Grant, Bart., M.A., Principal of the University of Edinburgh Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., D.C.L., F.R.S. Sir Charles Lyell, Bart., D.C.L., F.R.S., F.G.S. Dr. Lyon Playfair, C.B., M.P., F.R.S. Professor Christison, M.D., D.C.L., Pres. R.S.E. Professor Balfour, F.R.S. L. & E.	Professor A. Crum Brown, M.D., F.R.S.E. J. D. Marwick, Esq., F.R.S.E.
W. B. CARPENTER, Esq., M.D., LL.D., F.R.S., F.L.S. BRIGHTON, August 14, 1872.	The Right Hon. the Earl of Chichester, Lord-Lieutenant of the County of Sussex. His Grace the Duke of Norfolk His Grace the Duke of Richmond, K.G., P.C., D.C.L. His Grace the Duke of Devonshire, K.G., D.C.L., F.G.S. Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., F.G.S. Dr. Sharpey, LL.D., Sec. R.S., F.L.S. Joseph Prestwich, Esq., F.R.S., Pres. G.S.	Charles Carpenter, Esq. The Rev. Dr. Griffith. Henry Willett, Esq.
PROFESSOR ALEXANDER W. WILLIAMSON, Ph.D., F.R.S., F.C.S. BRADFORD, September 17, 1873.	The Right Hon. the Earl of Rosse, F.R.S., F.R.A.S. The Right Hon. Lord Houghton, D.C.L., F.R.S. The Right Hon. W. E. Forster, M.P. The Mayor of Bradford. Sir John Hawkshaw, F.R.S., F.G.S. J. P. Gassiot, Esq., D.C.L., F.R.S. Professor Phillips, D.C.L., F.R.S.	The Rev. J. R. Campbel, D.D. Richard Goddard, Esq. Peile Thompson, Esq.
PROFESSOR J. TYNDALL, D.C.L., LL.D., F.R.S. BELFAST, August 19, 1874.	The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S. The Right Hon. the Earl of Rosse, F.R.S. Sir Richard Wallace, Bart., M.P. The Rev. Dr. Henry. Dr. Andrews, F.R.S. The Rev. Dr. Robinson, F.R.S. Professor Stokes, D.C.L., F.R.S.	W. Quartus Ewart, Esq. Professor G. Fuller, C.E. T. Sinclair, Esq.
SIR JOHN HAWKSHAW, M.Inst.C.E., F.R.S., F.G.S. BRISTOL, August 25, 1875.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., F.R.S. The Mayor of Bristol Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., F.R.G.S. Dr. W. B. Carpenter, LL.D., F.R.S., F.L.S., F.G.S. W. Sanders, Esq., F.R.S., F.G.S.	W. Lant Carpenter, Esq., B.A., B.Sc., F.C.S. John H. Clarke, Esq.
PROFESSOR THOMAS ANDREWS, M.D., LL.D., F.R.S., Hon. F.R.S.E. GLASGOW, September 6, 1876.	His Grace the Duke of Argyll, K.T., LL.D., F.R.S., F.R.S.E., F.G.S. The Hon. the Lord Provost of Glasgow Sir William Stirling Maxwell, Bart., M.A., M.P. Professor Sir William Thomson, M.A., LL.D., D.C.L., F.R.S., F.R.S.E. Professor Allen Thomson, M.D., LL.D., F.R.S., F.R.S.E. Professor A. C. Ramsay, LL.D., F.R.S., F.G.S. James Young, Esq., F.R.S., F.C.S.	Dr. W. G. Blackie, F.R.G.S. James Grahame, Esq. J. D. Marwick, Esq.

PROFESSOR ALLEN THOMSON, M.D., LL.D., F.R.S., F.R.S.E. PLYMOUTH, August 15, 1877.	The Right Hon. the Earl of Mount-Edgcumbe The Right Hon. Lord Blachford, K.C.M.G. William Spottiswoode, Esq., M.A., LL.D., F.R.S., F.R.A.S., F.R.G.S. William Froude, Esq., M.A., C.E., F.R.S. Charles Spence Bate, Esq., F.R.S., F.L.S.	William Adams, Esq. William Square, Esq. Hamilton Whiteford, Esq.
WILLIAM SPOTTISWOODE, Esq., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. DUBLIN, August 14, 1878.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin His Grace the Duke of Abercorn, K.G. The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S., F.G.S. The Right Hon. the Earl of Rosse, B.A., D.C.L., F.R.S., F.R.A.S., M.R.I.A. The Right Hon. Lord O'Hagan, M.R.I.A. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S.	Professor R. S. Ball, M.A., F.R.S. James Goff, Esq. John Norwood, Esq., LL.D. Professor G. Sigerson, M.D.
PROFESSOR G. J. ALLMAN, M.D., LL.D., F.R.S., F.R.S.E., M.R.I.A., Pres. L.S. SHEFFIELD, August 20, 1879.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Hon. the Earl of Wharncliffe, F.R.G.S. W. H. Brittain, Esq. (Master Cutler) Professor T. H. Huxley, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S. Professor W. Odling, M.B., F.R.S., F.C.S.	H. Clifton Sorby, Esq., LL.D., F.R.S., F.G.S. J. F. Moss, Esq.
ANDREW CROMBIE RAMSAY, Esq., LL.D., F.R.S., V.P.G.S., Director-General of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology SWANSEA, August 25, 1880.	The Right Hon. the Earl of Jersey The Mayor of Swansea The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. H. Hussey Vivian, Esq., M.P., F.G.S. L. Ll. Dillwyn, Esq., M.P., F.L.S., F.G.S. J. Gwyn Jeffreys, Esq., LL.D., F.R.S., F.L.S., Treas. G.S., F.R.G.S.	W. Morgan Esq., Ph.D., F.C.S. James Strick, Esq.
SIR JOHN LUBBOCK, Bart., M.P., D.C.L., LL.D., F.R.S., Pres. L.S., F.G.S. YORK, August 31, 1881.	His Grace the Archbishop of York, D.D., F.R.S. The Right Hon. the Lord Mayor of York The Right Hon. Lord Houghton, D.C.L., F.R.S., F.R.G.S. The Venerable Archdeacon Creyke, M.A. The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S. Sir John Hawkshaw, M.Inst.C.E., F.R.S., F.G.S., F.R.G.S. Allen Thomson, Esq., M.D., LL.D., F.R.S. L. & E. Professor Allman, M.D., LL.D., F.R.S. L. & E., F.L.S.	Rev. Thomas Adams, M.A. Tempest Anderson, Esq., M.D., B.Sc.
C. W. SIEMENS, Esq., D.C.L., LL.D., F.R.S., F.C.S., M.Inst.C.E. SOUTHAMPTON, August 23, 1882.	The Right Hon. the Lord Mount-Temple Captain Sir F. J. Evans, K.C.B., F.R.S., F.R.A.S., F.R.G.S., Hydrographer to the Admiralty F. A. Abel, Esq., C.B., F.R.S., V.P.C.S., Director of the Chemical Establishment of the War Department Professor De Chaumont, M.D., F.R.S. Major-General A. C. Cooke, R.E., C.B., F.R.G.S., Director-General of the Ordnance Survey. Wyndham S. Portal, Esq. Professor Prestwich, M.A., F.R.S., F.G.S., F.C.S. Philip Lutley Sclater, Esq., M.A., Ph.D., F.R.S., F.L.S., F.G.S.	C. W. A. Jellicoe, Esq. John E. Le Feuvre, Esq. Morris Miles, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
ARTHUR CAYLEY, Esq., M.A., D.C.L., LL.D., F.R.S., V.P.R.A.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge SOUTHPORT, September 19, 1883.	The Right Hon. the Earl of Derby, M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl of Crawford and Balcarres, LL.D., F.R.S., F.R.A.S. The Right Hon. the Earl of Lathom Principal J. W. Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. J. G. Greenwood, Esq., LL.D., Vice-Chancellor of the Victoria University Professor H. E. Roscoe, Ph.D., LL.D., F.R.S., F.C.S.	J. H. Ellis, Esq. Dr. Vernon. T. W. Willis, Esq.
The RIGHT HON. LORD RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S., Professor of Experimental Physics in the University of Cambridge. MONTREAL, August 27, 1884.	His Excellency the Governor-General of Canada, G.C.M.G., LL.D. The Right Hon. Sir John Alexander Macdonald, K.C.B., D.C.L., LL.D. The Right Hon. Sir Lyon Playfair, K.C.B., M.P., LL.D., F.R.S. L. & E. The Hon. Sir Alexander Tilloch Galt, G.C.M.G. The Hon. Sir Charles Tupper, K.C.M.G. Chief Justice Sir A. A. Dorion, C.M.G. Principal Sir William Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. The Hon. Dr. Chauveau Professor Edward Frankland, M.D., D.C.L., Ph.D., LL.D., F.R.S., F.C.S. W. H. Hingston, Esq., M.D., D.C.L., L.R.C.S.E. Thomas Sterry Hunt, Esq., M.A., D.Sc., LL.D., F.R.S.	S. E. Dawson, Esq. R. A. Ramsay, Esq. S. Rivard, Esq. S. C. Stevenson, Esq. Thos. White, Esq., M.P.
The RIGHT HON. SIR LYON PLAYFAIR, K.C.B., M.P., Ph.D., LL.D., F.R.S., F.R.S.E., F.C.S. ABERDEEN, September 9, 1885.	His Grace the Duke of Richmond and Gordon, K.G., D.C.L., Chancellor of the University of Aberdeen The Right Hon. the Earl of Aberdeen, LL.D., Lord-Lieutenant of Aberdeenshire The Right Hon. the Earl of Crawford and Balcarres, M.A., LL.D., F.R.S., F.R.A.S. James Matthews, Esq., Lord Provost of the City of Aberdeen Professor Sir William Thomson, M.A., LL.D., F.R.S., F.R.S.E., F.R.A.S. Alexander Bain, Esq., M.A., LL.D., Rector of the University of Aberdeen The Very Rev. Principal Pirie, D.D., Vice-Chancellor of the University of Aberdeen Professor W. H. Flower, LL.D., F.R.S., F.L.S., Pres. Z.S., F.G.S., Director of the Natural History Museum, London Professor John Struthers, M.D., LL.D.	J. W. Crombie, Esq., M.A. Angus Fraser, Esq., M.A., M.D., F.C.S. Professor G. Pirie, M.A.
SIR J. WILLIAM DAWSON, C.M.G., M.A., LL.D., F.R.S., F.G.S., Principal and Vice-Chancellor of McGill University, Montreal, Canada BIRMINGHAM, September 1, 1886.	The Right Hon. the Earl of Bradford, Lord-Lieutenant of Shropshire. The Right Hon. Lord Leigh, D.C.L., Lord-Lieutenant of Warwickshire. The Right Hon. Lord Norton, K.C.M.G. The Right Hon. Lord Wrottesley, Lord-Lieutenant of Staffordshire The Right Rev. the Lord Bishop of Worcester, D.D. Thomas Martineau, Esq., Mayor of Birmingham Professor G. G. Stokes, M.A., D.C.L., LL.D., Pres. R.S. Professor W. A. Tilden, D.Sc., F.R.S., F.C.S. Rev. A. R. Vardy, M.A. Rev. H. W. Watson, D.Sc., F.R.S.	J. Barham Carslake, Esq. Rev. H. W. Crosskey, LL.D., F.G.S. Charles J. Hart, Esq.

SIR H. E. ROSCOE, M.P., D.C.L., LL.D., Ph.D., F.R.S., V.P.C.S. MANCHESTER, August 31, 1887.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S. The Right Hon. the Earl of Derby, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Rev. the Lord Bishop of Manchester, D.D. The Right Rev. the Bishop of Salford The Right Worshipful the Mayor of Manchester The Right Worshipful the Mayor of Salford The Vice-Chancellor of the Victoria University The Principal of the Owens College Sir William Roberts, B.A., M.D., F.R.S. Thomas Ashton, Esq., J.P., D.L. Oliver Heywood, Esq., J.P., D.L. James Prescott Joule, Esq., D.C.L., LL.D., F.R.S., F.R.S.E., F.C.S.	F. J. Faraday, Esq., F.L.S., F.S.S. Charles Hopkinson, Esq., B.Sc. Professor A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S. Professor A. H. Young, M.B., F.R.C.S.
SIR FREDERICK J. BRAMWELL, D.C.L., F.R.S., M.Inst.C.E. BATH, September 5, 1888.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somerset The Most Hon. the Marquess of Bath The Right Hon. and Right Rev. the Lord Bishop of Bath and Wells, D.D. The Right Rev. the Bishop of Clifton, D.D. The Right Worshipful the Mayor of Bath The Right Worshipful the Mayor of Bristol Sir F. A. Abel, C.B., D.C.L., F.R.S., V.P.C.S. The Venerable the Archdeacon of Bath, M.A. The Rev. Leonard Blomefield, M.A., F.L.S., F.G.S. Professor Michael Foster, M.A., M.D., LL.D., Sec. R.S., F.L.S., F.C.S. W. S. Gore-Langton, Esq., J.P., D.L. H. D. Skrine, Esq., J.P., D.L. Colonel R. P. Laurie, C.B., M.P. E. R. Wodehouse, Esq., M.P. Jerom Murch, Esq., J.P., D.L.	W. Pumphrey, Esq. J. L. Stothert, Esq., M.Inst.C.E. B. H. Watts, Esq.
PROFESSOR WILLIAM HENRY FLOWER, C.B., LL.D., F.R.S., F.R.C.S., Pres. Z.S., F.L.S., F.G.S., Director of the Natural History Departments of the British Museum NEWCASTLE-UPON-TYNE, September 11, 1889.	His Grace the Duke of Northumberland, K.G., D.C.L., LL.D., Lord-Lieutenant of Northumberland The Right Hon. the Earl of Durham, Lord-Lieutenant of Durham The Right Hon. the Earl of Ravensworth The Right Rev. the Lord Bishop of Newcastle, D.D. The Right Hon. Lord Armstrong, C.B., D.C.L., LL.D., F.R.S. The Right Hon. John Morley, M.P., LL.D. The Very Rev. the Warden of the University of Durham, D.D. The Right Worshipful the Mayor of Newcastle The Worshipful the Mayor of Gateshead Sir I. Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., M.Inst.C.E. Sir Charles Mark Palmer, Bart., M.P.	Professor P. Phillips Bedson, D.Sc., F.C.S. Professor J. Herman Merivale, M.A.
SIR FREDERICK AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., P.P.C.S., Hon.M.Inst.C.E. LEEDS, September 3, 1890.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S. The Most Hon. the Marquess of Ripon, K.G., G.C.S.I., C.I.E., F.R.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Sir Lyon Playfair, K.C.B., Ph.D., LL.D., M.P., F.R.S. The Right Hon. W. L. Jackson, M.P. The Mayor of Leeds Sir James Kitson, Bart., M.Inst.C.E. Sir Andrew Fairbairn, M.A.	J. Rawlinson Ford, Esq. Sydney Lupton, Esq., M.A. Professor L. C. Miall, F.L.S., F.G.S. Professor A. Smithells, B.Sc.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM HUGGINS, Esq., D.C.L., LL.D., Ph.D., F.R.S., F.R.A.S., Hon. F.R.S.E. CARDIFF, August 19, 1891.	The Right Hon. Lord Windsor, Lord-Lieutenant of Glamorganshire The Most Hon. the Marquess of Bute, K.T. The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., Sec.R.S., F.R.A.S. The Right Hon. Lord Tredegar The Right Hon. Lord Aberdare, G.C.B., F.R.S., F.R.G.S. Sir J. T. D. Llewelyn, Bart., F.Z.S. Sir Archibald Geikie, LL.D., D.Sc., For.Sec.R.S., F.R.S.E., Pres.G.S. Sir Robert Ball, LL.D., F.R.S., F.R.A.S., Royal Astronomer of Ireland	R. W. Atkinson, Esq., B.Sc., F.C.S., F.I.C. Professor H. W. Lloyd Tanner, M.A., F.R.A.S.
SIR ARCHIBALD GEIKIE, LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom EDINBURGH, August 3, 1892.	The Right Hon. the Lord Provost of Edinburgh The Most Hon. the Marquess of Lothian, K.T. The Right Hon. the Earl of Rosebery, LL.D., F.R.S., F.R.S.E. The Right Hon. J. H. A. Macdonald, C.B., LL.D., F.R.S., F.R.S.E. Principal Sir William Muir, K.C.S.I., D.C.L. Professor Sir Douglas Maclagan, M.D., Pres.R.S.E. Professor Sir William Turner, F.R.S., F.R.S.E. Professor P. G. Tait, M.A., F.R.S.E. Professor A. Crum Brown, M.D., F.R.S., F.R.S.E., Pres.C.S.	Professor G. F. Armstrong, M.A., M.Inst.C.E., F.R.S.E., F.G.S. F. Grant Ogilvie, Esq., M.A., B.Sc., F.R.S.E. John Harrison, Esq.
DR. J. S. BURDON SANDERSON, M.A., M.D., LL.D., D.C.L., F.R.S., F.R.S.E., Professor of Physiology in the University of Oxford NOTTINGHAM, September 13, 1893.	His Grace the Duke of St. Albans, Lord-Lieut. of Nottinghamshire His Grace the Duke of Devonshire, K.G., Chancellor of the University of Cambridge His Grace the Duke of Portland. His Grace the Duke of Newcastle The Right Hon. Lord Belper. The Mayor of Nottingham The Right Hon. Sir W. R. Grove, F.R.S. Sir John Turney, J.P. Professor Michael Foster, M.A., Sec.R.S. W. H. Ransom, Esq., M.D., F.R.S.	Professor F. Clowes, D.Sc. Professor W. H. Heaton, M.A. Arthur Williams, Esq.
The MOST HON. THE MARQUIS OF SALISBURY, K.G., D.C.L., F.R.S., Chancellor of the University of Oxford. OXFORD, August 8, 1894.	The Right Hon. the Earl of Jersey, G.C.M.G., Lord-Lieutenant of the County of Oxford The Right Hon. Lord Wantage, K.C.B., V.C., Lord-Lieutenant of Berkshire The Right Hon. the Earl of Rosebery, K.G., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Oxford, D.D. The Right Hon. Lord Rothschild, Lord-Lieutenant of Buckinghamshire The Right Hon. Lord Kelvin, D.C.L., Pres.R.S. The Rev. the Vice-Chancellor of the University of Oxford The Mayor of Oxford Sir W. R. Anson, D.C.L., Warden of All Souls College Sir Bernhard Samuelson, Bart., M.P., F.R.S. Sir Henry Dyke Acland, Bart., M.D., F.R.S., Regius Professor of Medicine The Rev. B. Price, D.D., F.R.S., Sedleian Professor of Natural Philosophy Dr. J. J. Sylvester, F.R.S., Savilian Professor of Geometry	Gilbert C. Bourne, Esq., M.A. G. C. Druce, Esq., M.A. D. H. Nagel, Esq., M.A.

CAPTAIN SIR DOUGLAS GALTON, K.C.B., D.C.L., LL.D., F.R.S., F.R.G.S., F.G.S. IPSWICH, September 11, 1895.	The Most Hon. the Marquis of Bristol, M.A., Lord-Lieutenant of the County of Suffolk The Right Hon. Lord Walsingham, LL.D., F.R.S., High Steward of the University of Cambridge The Right Hon. Lord Rayleigh, Sec.R.S., Lord-Lieutenant of Essex The Right Hon. Lord Gwydyr, M.A., High Steward of Ipswich The Right Hon. Lord Henniker, F.S.A. The Right Hon. Lord Rendlesham J. H. Bartlet, Esq., Mayor of Ipswich Sir G. G. Stokes, Bart., D.C.L., F.R.S. Dr. E. Frankland, D.C.L., F.R.S. Professor G. H. Darwin, M.A., F.R.S. Felix T. Cobbold, Esq., M.A.	G. H. Hewetson, Esq. S. A. Notcutt, Esq., B.A., LL.M., B.Sc. E. P. Ridley, Esq.
SIR JOSEPH LISTER, BART., D.C.L., LL.D., President of the Royal Society LIVERPOOL, September 16, 1896.	The Right Hon. the Earl of Derby, G.C.B., Lord Mayor of Liverpool The Right Hon. the Earl of Sefton, K.G., Lord-Lieutenant of Lancashire Sir W. B. Forwood, J.P. Sir Henry E. Roscoe, D.C.L., F.R.S. The Principal of University College, Liverpool W. Rathbone, Esq., LL.D. W. Crookes, Esq., F.R.S., V.P.C.S. T. H. Ismay, Esq., J.P., D.L. Professor A. Liversidge, F.R.S.	Professor W. A. Herdman, F.R.S. Isaac C. Thompson, Esq., F.L.S. W. E. Willink, Esq.
SIR JOHN EVANS, K.C.B., D.C.L., LL.D., Sc.D., Treas.R.S., F.S.A., For.Sec.G.S. TORONTO, August 18, 1897.	His Excellency the Right Hon. the Earl of Aberdeen, G.C.M.G., Governor-General of the Dominion of Canada The Right Hon. Lord Rayleigh, M.A., D.C.L., F.R.S. The Right Hon. Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S., F.R.S.E. The Hon. Sir Wilfrid Laurier, G.C.M.G., Prime Minister of the Dominion of Canada His Honour the Lieutenant-Governor of the Province of Ontario The Hon. the Premier of the Province of Ontario The Hon. the Minister of Education for the Province of Ontario The Hon. Sir Charles Tupper, Bart., G.C.M.G., C.B., LL.D. The Hon. Sir Donald A. Smith, G.C.M.G., LL.D., High Commissioner for Canada Sir William Dawson, C.M.G., F.R.S. The Mayor of Toronto Professor J. Loudon, M.A., LL.D., President of the University of Toronto	Professor A. B. Macallum, M.B., Ph.D. B. E. Walker, Esq., F.G.S. J. S. Willison, Esq.
SIR WILLIAM CROOKES, F.R.S., V.P.C.S. BRISTOL, September 7, 1898.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Rev. the Lord Bishop of Bristol, D.D. The Right Hon. Sir Edward Fry, D.C.L., F.R.S., F.S.A. Sir F. J. Bramwell, Bart., D.C.L., LL.D., F.R.S. The Right Worshipful the Mayor of Bristol The Principal of University College, Bristol The Master of the Society of Merchant Venturers of Bristol John Beddoe, Esq., M.D., LL.D., F.R.S. Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.S.A., F.G.S.	Arthur Lee, Esq., J.P. Bertram Rogers, Esq., M.D.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR SIR MICHAEL FOSTER, K.C.B., M.D., D.C.L., LL.D., Sec. R.S. DOVER, September 13, 1899.	His Grace the Lord Archbishop of Canterbury, D.D. The Most Hon. the Marquis of Salisbury, K.G., M.A., D.C.L., F.R.S. The Mayor of Dover. The Major-General Commanding the South-Eastern District. The Right Hon. A. Akers-Douglas, M.P. The Very Rev. F. W. Farrar, D.D., F.R.S., Dean of Canterbury. Sir J. Norman Lockyer, K.C.B., F.R.S. Professor G. H. Darwin, M.A., LL.D., F.R.S., Pres. R.A.S.	E. Wollaston Knocker, Esq., C.B. W. H. Pendlebury, Esq., M.A.
PROFESSOR SIR WILLIAM TURNER, M.B., D.Sc., D.C.L., LL.D., F.R.S. BRADFORD, September 5, 1900.	The Right Hon. the Earl of Scarbrough, Lord-Lieutenant of the West Riding of Yorkshire. His Grace the Duke of Devonshire, K.G., D.C.L., LL.D., F.R.S. The Most Hon. the Marquis of Ripon, K.G., G.C.S.I., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Lord Masham His Worship the Mayor of Bradford The Hon. H. E. Butler, Lord of the Manor, Bradford. Sir Alexander Binnie, M.Inst.C.E., F.G.S. Professor A. W. Rücker, M.A., D.Sc., Sec.R.S. Dr. T. E. Thorpe, Sc.D., F.R.S., Pres.C.S. Principal N. Bodington, Litt.D., Vice-Chancellor of the Victoria University Professor L. C. Miall, F.R.S.	Ramsden Bacchus, Esq. J. E. Fawcett, Esq., J.P. Frederick Stevens, Esq.
PROFESSOR A. W. RÜCKER, M.A., LL.D., D.Sc., Sec.R.S. GLASGOW, September 11, 1901.	The Right Hon. the Earl of Glasgow, G.C.M.G. The Right Hon. the Lord Blythswood, LL.D., D.L. The Right Hon. the Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S. Samuel Chisholm, Esq., the Hon. the Lord Provost of Glasgow Very Rev. R. Herbert Story, D.D., LL.D., Principal of the University of Glasgow Sir John Maxwell Stirling-Maxwell, Bart., M.P., D.L. Sir Andrew Noble, K.C.B., D.C.L., F.R.S. Sir Archibald Geikie, D.C.L., LL.D., F.R.S. Sir W. T. Thiselton-Dyer, K.C.M.G., C.I.E., F.R.S. James Parker Smith, Esq., M.P., D.L. John Inglis, Esq., LL.D. Professor John Cleland, M.D., LL.D., D.Sc., F.R.S.	Sir J. D. Marwick, LL.D., D.L., F.R.S.E. Professor John Young, M.D. Professor Magnus Maclean, D.Sc., F.R.S.E.
PROFESSOR JAMES DEWAR, M.A., LL.D., D.Sc., F.R.S. BELFAST, September 10, 1902.	His Grace the Duke of Abercorn, K.G., H.M. Lieutenant of the County of Donegal The Marquis of Londonderry, K.G., H.M. Lieutenant of the City of Belfast Sir Francis Macnaghten, Bart., H.M. Lieutenant of the County of Antrim The Right Hon. the Earl of Shaftesbury, D.L. The Right Hon. the Earl of Rosse, K.P., D.C.L., LL.D., F.R.S. The Right Hon. Thomas Sinclair, D.Lit. Sir William Quartus Ewart, Bart., M.A. The Lord Mayor of Belfast The President of Queen's College, Belfast Professor E. Ray Lankester, M.A., F.R.S. Professor Peter Redfern, M.D.	John Brown, F.R.S. Godfrey W. Ferguson. Professor Maurice FitzGerald, B.A.

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1835–36	Rev. W. Vernon Harcourt, F.R.S., and F. Baily, Esq., F.R.S.
1836–37	Rev. W. Vernon Harcourt, F.R.S., and R. I. Murchison, Esq., F.R.S.
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1845–50	Lieut.-Colonel E. Sabine, F.R.S.
1850–52	General E. Sabine, F.R.S., and J. F. Royle, Esq., F.R.S.
1852–53	J. F. Royle, Esq., F.R.S.
1853–59	General E. Sabine, F.R.S.
1859–61	Prof. R. Walker, F.R.S.
1861–62	W. Hopkins, Esq., F.R.S.
1862–63	W. Hopkins, Esq., F.R.S., and Prof. J. Phillips, F.R.S.
1863–65	W. Hopkins, Esq., F.R.S., and F. Galton, Esq., F.R.S.
1865–66	F. Galton, Esq., F.R.S.
1866–68	F. Galton, Esq., F.R.S., and Dr. T. A. Hirst, F.R.S.
1868–71	Dr. T. A. Hirst, F.R.S., and Dr. T. Thomson, F.R.S.
1871–72	Dr. T. Thomson, F.R.S., and Capt. Douglas Galton, F.R.S.
1872–76	Capt. D. Galton, F.R.S., and Dr. Michael Foster, F.R.S.
1876–81	Capt. D. Galton, F.R.S., and Dr. P. L. Sclater, F.R.S.
1881–82	Capt. D. Galton, F.R.S., and Prof. F. M. Balfour, F.R.S.
1882–83	Capt. Douglas Galton, F.R.S.
1883–95	Sir Douglas Galton, F.R.S., and A. G. Vernon Harcourt, Esq., F.R.S.
1895–97	A. G. Vernon Harcourt, Esq., F.R.S., and Prof. E. A. Schäfer, F.R.S.
1897–1900	Prof. Schäfer, F.R.S., and Sir W. C. Roberts-Austen, F.R.S.
1900–02	Sir W. C. Roberts-Austen, F.R.S., and Dr. D. H. Scott, F.R.S.
1902	Dr. D. H. Scott, F.R.S., and Major P. A. MacMahon, F.R.S.

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1832–62	Prof. John Phillips, F.R.S.
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1881	G. Griffith, Esq., M.A., *Acting Secretary.*
1881–85	Prof. T. G. Bonney, F.R.S., *Secretary.*
1885–90	A. T. Atchison, Esq., M.A., *Secretary.*
1890	G. Griffith, Esq., M.A. *Acting Secretary.*
1890–1902	G. Griffith, Esq., M.A.
1902	J. G. Garson, Esq., M.D.

Presidents and Secretaries of the Sections of the Association.

Date and Place	Presidents	Secretaries
MATHEMATICAL AND PHYSICAL SCIENCES.		
COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.		
1832. Oxford	Davies Gilbert, D.C.L., F.R.S.	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.
SECTION A.—MATHEMATICS AND PHYSICS.		
1835. Dublin	Rev. Dr. Robinson	Prof. Sir W. R. Hamilton, Prof. Wheatstone.
1836. Bristol	Rev. William Whewell, F.R.S.	Prof. Forbes, W. S. Harris, F. W. Jerrard.
1837. Liverpool	Sir D. Brewster, F.R.S.	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S.	J. D. Chance, W. Snow Harris, Prof. Stevelly.
1840. Glasgow	Prof. Forbes, F.R.S.	Rev. Dr. Forbes, Prof. Stevelly, Arch. Smith.
1841. Plymouth	Rev. Prof. Lloyd, F.R.S.	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork	Prof. M'Culloch, M.R.I.A.	J. Nott, Prof. Stevelly.
1844. York	The Earl of Rosse, F.R.S.	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge	The Very Rev. the Dean of Ely.	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton.	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
1847. Oxford	Rev. Prof. Powell, M.A., F.R.S.	Rev. H. Price, Prof. Stevelly, G. G. Stokes.
1848. Swansea	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
1850. Edinburgh	Prof. J. D. Forbes, F.R.S., Sec. R.S.E.	W. J. Macquorn Rankine, Prof. Smyth, Prof. Stevelly, Prof. G. G. Stokes.
1851. Ipswich	Rev. W. Whewell, D.D., F.R.S.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast	Prof. W. Thomson, M.A., F.R.S., F.R.S.E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull	The Very Rev. the Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.
1854. Liverpool	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.
1855. Glasgow	Rev. Prof. Kelland, M.A., F.R.S., F.R.S.E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S.	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.
1857. Dublin	Rev. T. R. Robinson, D.D., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.

Date and Place	Presidents	Secretaries
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1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. G. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.
1868. Norwich	Prof. J. Tyndall, LL.D., F.R.S.	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.
1869. Exeter	Prof. J. J. Sylvester, LL.D., F.R.S.	Prof. G. C. Foster, R. B. Hayward, W. K. Clifford.
1870. Liverpool	J. Clerk Maxwell, M.A., LL.D., F.R.S.	Prof. W. G. Adams, W. K. Clifford, Prof. G. C. Foster, Rev. W. Allen Whitworth.
1871. Edinburgh	Prof. P. G. Tait, F.R.S.E.	Prof. W. G. Adams, J. T. Bottomley, Prof. W. K. Clifford, Prof. J. D. Everett, Rev. R. Harley.
1872. Brighton	W. De La Rue, D.C.L., F.R.S.	Prof. W. K. Clifford, J. W. L. Glaisher, Prof. A. S. Herschel, G. F. Rodwell.
1873. Bradford	Prof. H. J. S. Smith, F.R.S.	Prof. W. K. Clifford, Prof. Forbes, J. W. L. Glaisher, Prof. A. S. Herschel.
1874. Belfast	Rev. Prof. J. H. Jellett, M.A., M.R.I.A.	J. W. L. Glaisher, Prof. Herschel, Randal Nixon, J. Perry, G. F. Rodwell.
1875. Bristol	Prof. Balfour Stewart, M.A., LL.D., F.R.S.	Prof. W. F. Barrett, J. W. L. Glaisher, C. T. Hudson, G. F. Rodwell.
1876. Glasgow	Prof. Sir W. Thomson, M.A., D.C.L., F.R.S.	Prof. W. F. Barrett, J. T. Bottomley, Prof. G. Forbes, J. W. L. Glaisher, T. Muir.
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1879. Sheffield	George Johnstone Stoney, M.A., F.R.S.	A. H. Allen, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1880. Swansea	Prof. W. Grylls Adams, M.A., F.R.S.	W. E. Ayrton, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
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1883. Southport	Prof. O. Henrici, Ph.D., F.R.S.	W. M. Hicks, Prof. O. J. Lodge, D. MacAlister, Prof. R. C. Rowe.
1884. Montreal	Prof. Sir W. Thomson, M.A., LL.D., D.C.L., F.R.S.	C. Carpmael, W. M. Hicks, A. Johnson, O. J. Lodge, D. MacAlister.

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1893. Nottingham	R. T. Glazebrook, M.A., F.R.S.	W. T. A. Emtage, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
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1896. Liverpool	Prof. J. J. Thomson, M.A., D.Sc., F.R.S.	Prof. W. H. Heaton, J. L. Howard, Prof. A. Lodge, G. T. Walker, W. Watson.
1897. Toronto	Prof. A. R. Forsyth, M.A., F.R.S.	Prof. W. H. Heaton, J. C. Glashan, J. L. Howard, Prof. J. C. McLennan.
1898. Bristol	Prof. W. E. Ayrton, F.R.S.	A. P. Chattock, J. L. Howard, C. H. Lees, W. Watson, E. T. Whittaker.
1899. Dover	Prof. J. H. Poynting, F.R.S.	J. L. Howard, C. H. Lees, W. Watson, E. T. Whittaker.
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1902. Belfast	Prof. J. Purser, LL.D., M.R.I.A. —*Dep. of Astronomy*, Prof. A. Schuster, F.R.S.	H. S. Carslaw, A. R. Hinks, A. Larmor, C. H. Lees, Prof. W. B. Morton, A. W. Porter.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY.

1832. Oxford	John Dalton, D.C.L., F.R.S.	James F. W. Johnston.
1833. Cambridge	John Dalton, D.C.L., F.R.S.	Prof. Miller.
1834. Edinburgh	Dr. Hope	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

1835. Dublin	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol	Rev. Prof. Cumming	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool	Michael Faraday, F.R.S.	Prof. Johnston, Prof. Miller, Dr. Reynolds.
1838. Newcastle	Rev. William Whewell, F.R.S.	Prof. Miller, H. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Dr. Golding Bird, Dr. J. B. Melson.
1840. Glasgow	Dr. Thomas Thomson, F.R.S.	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth	Dr. Daubeny, F.R.S.	J. Prideaux, R. Hunt, W. M. Tweedy.
1842. Manchester	John Dalton, D.C.L., F.R.S.	Dr. L. Playfair, R. Hunt, J. Graham.

Date and Place	Presidents	Secretaries
1843. Cork	Prof. Apjohn, M.R.I.A.	R. Hunt, Dr. Sweeny.
1844. York	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.
1846. Southampton.	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt, Prof. Solly.
1848. Swansea	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.	R. Hunt, G. Shaw.
1850. Edinburgh	Dr. Christison, V.P.R.S.E.	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich	Prof. Thomas Graham, F.R.S.	T. J. Pearsall, W. S. Ward.
1852. Belfast	Thomas Andrews, M.D., F.R.S.	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow	Dr. Lyon Playfair, C.B., F.R.S.	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S.	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen	Dr. Lyon Playfair, C.B., F.R.S.	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford	Prof. B. C. Brodie, F.R.S.	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge	Prof. W. H. Miller, M.A., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath	W. Odling, M.B., F.R.S.	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S.	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich	Prof. E. Frankland, F.R.S.	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.
1869. Exeter	Dr. H. Debus, F.R.S.	Prof. A. Crum Brown, Dr. W. J. Russell, Dr. Atkinson.
1870. Liverpool	Prof. H. E. Roscoe, B.A., F.R.S.	Prof. A. Crum Brown, A. E. Fletcher, Dr. W. J. Russell.
1871. Edinburgh	Prof. T. Andrews, M.D., F.R.S.	J. Y. Buchanan, W. N. Hartley, T. E. Thorpe.
1872. Brighton	Dr. J. H. Gladstone, F.R.S.	Dr. Mills, W. Chandler Roberts, Dr. W. J. Russell, Dr. T. Wood.
1873. Bradford	Prof. W. J. Russell, F.R.S.	Dr. Armstrong, Dr. Mills, W. Chandler Roberts, Dr. Thorpe.
1874. Belfast	Prof. A. Crum Brown, M.D., F.R.S.E.	Dr. T. Cranstoun Charles, W. Chandler Roberts, Prof. Thorpe.
1875. Bristol	A. G. Vernon Harcourt, M.A., F.R.S.	Dr. H. E. Armstrong, W. Chandler Roberts, W. A. Tilden.
1876. Glasgow	W. H. Perkin, F.R.S.	W. Dittmar, W. Chandler Roberts, J. M. Thomson, W. A. Tilden.

Date and Place	Presidents	Secretaries
1877. Plymouth...	F. A. Abel, F.R.S.............. ..	Dr. Oxland, W. Chandler Roberts, J. M. Thomson.
1878. Dublin	Prof. Maxwell Simpson, M.D., F.R.S.	W. Chandler Roberts, J. M. Thomson, Dr. C. R. Tichborne, T. Wills.
1879. Sheffield ...	Prof. Dewar, M.A., F.R.S. ...	H. S. Bell, W. Chandler Roberts, J. M. Thomson.
1880. Swansea ...	Joseph Henry Gilbert, Ph.D., F.R.S.	P. P. Bedson, H. B. Dixon, W. R. E. Hodgkinson, J. M. Thomson.
1881. York.........	Prof. A. W. Williamson, F.R.S.	P. P. Bedson, H. B. Dixon, T. Gough.
1882. Southampton.	Prof. G. D. Liveing, M.A., F.R.S.	P. Phillips Bedson, H. B. Dixon, J. L. Notter.
1883. Southport	Dr. J. H. Gladstone, F.R.S...	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley.
1884. Montreal ...	Prof. Sir H. E. Roscoe, Ph.D., LL.D., F.R.S.	Prof. P. Phillips Bedson, H. B. Dixon, T. McFarlane, Prof. W. H. Pike.
1885. Aberdeen ...	Prof. H. E. Armstrong, Ph.D., F.R.S., Sec. C.S.	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley, Dr. W. J. Simpson.
1886. Birmingham	W. Crookes, F.R.S., V.P.C.S.	P. P. Bedson, H. B. Dixon, H. F. Morley, W. W. J. Nicol, C. J. Woodward.
1887. Manchester	Dr. E. Schunck, F.R.S.	Prof. P. Phillips Bedson, H. Forster Morley, W. Thomson.
1888. Bath.........	Prof. W. A. Tilden, D.Sc., F.R.S., V.P.C.S.	Prof. H. B. Dixon, H. Forster Morley, R. E. Moyle, W. W. J. Nicol.
1889. Newcastle-upon-Tyne	Sir I. Lowthian Bell, Bart., D.C.L., F.R.S.	H. Forster Morley, D. H. Nagel, W. W. J. Nicol, H. L. Pattinson, jun.
1890. Leeds	Prof. T. E. Thorpe, B.Sc., Ph.D., F.R.S., Treas. C.S.	C. H. Bothamley, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1891. Cardiff	Prof. W. C. Roberts-Austen, C.B., F.R.S.	C. H. Bothamley, H. Forster Morley, W. W. J. Nicol, G. S. Turpin.
1892. Edinburgh	Prof. H. McLeod, F.R.S.......	J. Gibson, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1893. Nottingham	Prof. J. Emerson Reynolds, M.D., D.Sc., F.R.S.	J. B. Coleman, M. J. R. Dunstan, D. H. Nagel, W. W. J. Nicol.
1894. Oxford......	Prof. H. B. Dixon, M.A., F.R.S.	A. Colefax, W. W. Fisher, Arthur Harden, H. Forster Morley.

SECTION B (*continued*).—CHEMISTRY.

Date and Place	Presidents	Secretaries
1895. Ipswich ...	Prof. R. Meldola, F.R.S.	E. H. Fison, Arthur Harden, C. A. Kohn, J. W. Rodger.
1896. Liverpool...	Dr. Ludwig Mond, F.R.S.	Arthur Harden, C. A. Kohn.
1897 Toronto ...	Prof. W. Ramsay, F.R.S.......	Prof. W. H. Ellis, A. Harden, C. A. Kohn, Prof. R. F. Ruttan.
1898. Bristol	Prof. F. R. Japp, F.R.S.	C. A. Kohn, F. W. Stoddart, T. K. Rose.
1899. Dover	Horace T. Brown, F.R.S.......	A. D. Hall, C. A. Kohn, T. K. Rose, Prof. W. P. Wynne.
1900. Bradford ...	Prof. W. H. Perkin, F.R.S. ...	W. M. Gardner, F. S. Kipping, W. J. Pope, T. K. Rose.
1901. Glasgow ...	Prof. Percy F. Frankland, F.R.S.	W. C. Anderson, G. G. Henderson, W. J. Pope, T. K. Rose.
1902. Belfast......	Prof. E. Divers, F.R.S..........	R. F. Blake, M. O. Forster, Prof. G. G. Henderson, Prof. W. J. Pope.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

Date and Place	Presidents	Secretaries
1832. Oxford......	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge.	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh.	Prof. Jameson	J. Phillips, T. J. Torrie, Rev. J. Yates.

Date and Place	Presidents	Secretaries
	SECTION C.—GEOLOGY AND GEOGRAPHY.	
1835. Dublin	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol	Rev. Dr. Buckland, F.R.S.—*Geog.*, R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*, Capt. H. M. Denham, R.N.
1838. Newcastle..	C. Lyell, F.R.S., V.P.G.S.—*Geography*, Lord Prudhoe.	W. C. Trevelyan, Capt. Portlock.—*Geography*, Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, H. Murray, H. E. Strickland, J. Scoular.
1841. Plymouth...	H. T. De la Beche, F.R.S. ...	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork	Richard E. Griffith, F.R.S. ...	F. M. Jennings, H. E. Strickland.
1844. York	Henry Warburton, Pres. G. S.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge.	Rev. Prof. Sedgwick, M.A. F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton.	Leonard Horner, F.R.S.	Robert A. Austen, Dr. J. H. Norton, Prof. Oldham, Dr. C. T. Beke.
1847. Oxford......	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, F.R.S.	S. Benson, Prof. Oldham, Prof. Ramsay
1849. Birmingham	Sir Charles Lyell, F.R.S.......	J. B. Jukes, Prof. Oldham, A. C. Ramsay.
1850. Edinburgh[1]	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Prof. Nicol.
	SECTION C (*continued*).—GEOLOGY.	
1851. Ipswich ...	William Hopkins, M.A., F.R.S.	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast......	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull	Prof. Sedgwick, F.R.S.........	Prof. Harkness, William Lawton.
1854. Liverpool..	Prof. Edward Forbes, F.R.S.	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S....	J. Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S....	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin	The Lord Talbot de Malahide	Prof. Harkness, G. Sanders, R. H. Scott.
1858. Leeds	William Hopkins, M.A., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir H. C. Sorby.
1860. Oxford	Rev. Prof. Sedgwick, F.R.S...	Prof. Harkness, E. Hull, J. W. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle	Prof. Warington W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.

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[1] Geography was constituted a separate Section, see page lxv.

Date and Place	Presidents	Secretaries
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B., F.R.S.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee	Archibald Geikie, F.R.S.	E. Hull, W. Pengelly, H. Woodward.
1868. Norwich	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.
1869. Exeter	Prof. R. Harkness, F.R.S., F.G.S.	W. Pengelly, W. Boyd Dawkins, Rev. H. H. Winwood.
1870. Liverpool	Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S.	W. Pengelly, Rev. H. H. Winwood, W. Boyd Dawkins, G. H. Morton.
1871. Edinburgh	Prof. A. Geikie, F.R.S., F.G.S.	R. Etheridge, J. Geikie, T. McKenny Hughes, L. C. Miall.
1872. Brighton	R. A. C. Godwin-Austen, F.R.S., F.G.S.	L. C. Miall, George Scott, William Topley, Henry Woodward.
1873. Bradford	Prof. J. Phillips, F.R.S.	L. C. Miall, R. H. Tiddeman, W. Topley.
1874. Belfast	Prof. Hull, M.A., F.R.S., F.G.S.	F. Drew, L. C. Miall, R. G. Symes, R. H. Tiddeman.
1875. Bristol	Dr. T. Wright, F.R.S.E., F.G.S.	L. C. Miall, E. B. Tawney, W. Topley.
1876. Glasgow	Prof. John Young, M.D.	J. Armstrong, F. W. Rudler, W. Topley.
1877. Plymouth	W. Pengelly, F.R.S., F.G.S.	Dr. Le Neve Foster, R. H. Tiddeman, W. Topley.
1878. Dublin	John Evans, D.C.L., F.R.S., F.S.A., F.G.S.	E. T. Hardman, Prof. J. O'Reilly, R. H. Tiddeman.
1879. Sheffield	Prof. P. M. Duncan, F.R.S.	W. Topley, G. Blake Walker.
1880. Swansea	H. C. Sorby, F.R.S., F.G.S.	W. Topley, W. Whitaker.
1881. York	A. C. Ramsay, LL.D., F.R.S., F.G.S.	J. E. Clark, W. Keeping, W. Topley, W. Whitaker.
1882. Southampton.	R. Etheridge, F.R.S., F.G.S.	T. W. Shore, W. Topley, E. Westlake, W. Whitaker.
1883. Southport	Prof. W. C. Williamson, LL.D., F.R.S.	R. Betley, C. E. De Rance, W. Topley, W. Whitaker.
1884. Montreal	W. T. Blanford, F.R.S., Sec. G.S.	F. Adams, Prof. E. W. Claypole, W. Topley, W. Whitaker.
1885. Aberdeen	Prof. J. W. Judd, F.R.S., Sec. G.S.	C. E. De Rance, J. Horne, J. J. H. Teall, W. Topley.
1886. Birmingham	Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.	W. J. Harrison, J. J. H. Teall, W. Topley, W. W. Watts.
1887. Manchester	Henry Woodward, LL.D., F.R.S., F.G.S.	J. E. Marr, J. J. H. Teall, W. Topley, W. W. Watts.
1888. Bath	Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.	Prof. G. A. Lebour, W. Topley, W. W. Watts, H. B. Woodward.
1889. Newcastle-upon-Tyne	Prof. J. Geikie, LL.D., D.C.L., F.R.S., F.G.S.	Prof. G. A. Lebour, J. E. Marr, W. W. Watts, H. B. Woodward.
1890. Leeds	Prof. A. H. Green, M.A., F.R.S., F.G.S.	J. E. Bedford, Dr. F. H. Hatch, J. E. Marr, W. W. Watts.
1891. Cardiff	Prof. T. Rupert Jones, F.R.S., F.G.S.	W. Galloway, J. E. Marr, Clement Reid, W. W. Watts.
1892. Edinburgh	Prof. C. Lapworth, LL.D., F.R.S., F.G.S.	H. M. Cadell, J. E. Marr, Clement Reid, W. W. Watts.
1893. Nottingham	J. J. H. Teall, M.A., F.R.S., F.G.S.	J. W. Carr, J. E. Marr, Clement Reid, W. W. Watts.
1894. Oxford	L. Fletcher, M.A., F.R.S.	F. A. Bather, A. Harker, Clement Reid, W. W. Watts.
1895. Ipswich	W. Whitaker, B.A., F.R.S.	F. A. Bather, G. W. Lamplugh, H. A. Miers, Clement Reid.
1896. Liverpool	J. E. Marr, M.A., F.R.S.	J. Lomas, Prof. H. A. Miers, C. Reid.
1897. Toronto	Dr. G. M. Dawson, C.M.G., F.R.S.	Prof. A. P. Coleman, G. W. Lamplugh, Prof. H. A. Miers.

Date and Place	Presidents	Secretaries
1898. Bristol	W. H. Hudleston, F.R.S.	G. W. Lamplugh, Prof. H. A. Miers, H. Pentecost.
1899. Dover	Sir Archibald Geikie, F.R.S.	J. W. Gregory, G. W. Lamplugh, Capt. McDakin, Prof. H. A. Miers.
1900. Bradford ...	Prof. W. J. Sollas, F.R.S. ...	H. L. Bowman, Rev. W. Lower Carter, G. W. Lamplugh, H. W. Monckton.
1901. Glasgow ...	John Horne, F.R.S.	H. L. Bowman, H. W. Monckton.
1902. Belfast	Lieut.-Gen. C. A. McMahon, F.R.S.	H. L. Bowman, H. W. Monckton, J. St. J. Phillips, H. J. Seymour.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford	Rev. P. B. Duncan, F.G.S. ...	Rev. Prof. J. S. Henslow.
1833. Cambridge[1]	Rev. W. L. P. Garnons, F.L.S.	C. C. Babington, D. Don.
1834. Edinburgh .	Prof. Graham	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin	Dr. Allman	J. Curtis, Dr. Litton.
1836. Bristol	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart.	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S.	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth...	John Richardson, M.D., F.R.S.	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork	William Thompson, F.L.S. ...	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York	Very Rev. the Dean of Manchester.	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S. ...	Dr. Lankester, T. V. Wollaston.
1846. Southampton.	Sir J. Richardson, M.D., F.R.S.	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford	H. E. Strickland, M.A., F.R.S.	Dr. Lankester, Dr. Melville, T. V. Wollaston.

SECTION D (*continued*).—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see p. lxiv.]

1848. Swansea ...	L. W. Dillwyn, F.R.S.	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.
1850. Edinburgh	Prof. Goodsir, F.R.S. L. & E.	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich ...	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.

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[1] At this Meeting Physiology and Anatomy were made a separate Committee for Presidents and Secretaries of which see p. lxiv.

Date and Place	Presidents	Secretaries
1852. Belfast......	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull	C. C. Babington, M.A., F.R.S.	Robert Harrison, Dr. E. Lankester.
1854. Liverpool...	Prof. Balfour, M.D., F.R.S....	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E.	William Keddie, Dr. Lankester.
1856. Cheltenham	Thomas Bell, F.R.S., Pres.L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin......	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds	C. C. Babington, M.A., F.R.S.	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen...	Sir W. Jardine, Bart., F.R.S.E.	Prof. Dickie, M.D., Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford......	Rev. Prof. Henslow, F.L.S....	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester	Prof. C. C. Babington, F.R.S.	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge	Prof. Huxley, F.R.S.	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle	Prof. Balfour, M.D., F.R.S....	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath.........	Dr. John E. Gray, F.R.S. ...	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham[1]	T. Thomson, M.D., F.R.S. ...	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D (*continued*).—BIOLOGY.

1866. Nottingham	Prof. Huxley, F.R.S.—*Dep. of Physiol.*, Prof. Humphry, F.R.S.—*Dep. of Anthropol.*, A. R. Wallace.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee ...	Prof. Sharpey, M.D., Sec. R.S. —*Dep. of Zool. and Bot.*, George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich ...	Rev. M. J. Berkeley, F.L.S. —*Dep. of Physiology*, W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Lawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.
1869. Exeter......	George Busk, F.R.S., F.L.S. —*Dep. of Bot. and Zool.*, C. Spence Bate, F.R.S.—*Dep. of Ethno.*, E. B. Tylor.	Dr. T. S. Cobbold, Prof. M. Foster, E. Ray Lankester, Prof. Lawson, H. T. Stainton, Rev. H. B. Tristram.
1870. Liverpool...	Prof. G. Rolleston, M.A., M.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. M. Foster, M.D., F.L.S.—*Dep. of Ethno.*, J. Evans, F.R.S.	Dr. T. S. Cobbold, Sebastian Evans, Prof. Lawson, Thos. J. Moore, H. T. Stainton, Rev. H. B. Tristram, C. Staniland Wake, E. Ray Lankester.
1871. Edinburgh .	Prof. Allen Thomson, M.D., F.R.S.—*Dep. of Bot. and Zool.*, Prof. Wyville Thomson, F.R.S.—*Dep. of Anthropol.*, Prof. W. Turner, M.D.	Dr. T. R. Fraser, Dr. Arthur Gamgee, E. Ray Lankester, Prof. Lawson, H. T. Stainton, C. Staniland Wake, Dr. W. Rutherford, Dr. Kelburne King.
1872. Brighton ...	Sir J. Lubbock, Bart., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Burdon Sanderson, F.R.S.—*Dep. of Anthropol.*, Col. A. Lane Fox, F.G.S.	Prof. Thiselton-Dyer, H. T. Stainton, Prof. Lawson, F. W. Rudler, J. H. Lamprey, Dr. Gamgee, E. Ray Lankester, Dr. Pye-Smith.

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[1] The title of Section D was changed to Biology.

Date and Place	Presidents	Secretaries
1873. Bradford ...	Prof. Allman, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Rutherford, M.D.—*Dep. of Anthropol.*, Dr. Beddoe, F.R.S.	Prof. Thiselton-Dyer, Prof. Lawson, R. M‘Lachlan, Dr. Pye-Smith, E. Ray Lankester, F. W. Rudler, J. H. Lamprey.
1874. Belfast	Prof. Redfern, M.D.—*Dep. of Zool. and Bot.*, Dr. Hooker, C.B., Pres. R.S.—*Dep. of Anthrop.*, Sir W. R. Wilde, M.D.	W. T. Thiselton-Dyer, R. O. Cunningham, Dr. J. J. Charles, Dr. P. H. Pye-Smith, J. J. Murphy, F. W. Rudler.
1875. Bristol	P. L. Sclater, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Cleland, F.R.S.—*Dep. of Anth.*, Prof. Rolleston, F.R.S.	E. R. Alston, Dr. McKendrick, Prof. W. R. M‘Nab, Dr. Martyn, F. W. Rudler, Dr. P. H. Pye-Smith, Dr. W. Spencer.
1876. Glasgow ...	A. Russel Wallace, F.L.S.—*Dep. of Zool. and Bot.*, Prof. A. Newton, F.R.S.—*Dep. of Anat. and Physiol.*, Dr. J. G. McKendrick.	E. R. Alston, Hyde Clarke, Dr Knox, Prof. W. R. M‘Nab, Dr. Muirhead, Prof. Morrison Watson.
1877. Plymouth...	J. Gwyn Jeffreys, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Macalister.—*Dep. of Anthropol.*, F. Galton, F.R.S.	E. R. Alston, F. Brent, Dr. D. J. Cunningham, Dr. C. A. Hingston, Prof. W. R. M‘Nab, J. B. Rowe, F. W. Rudler.
1878. Dublin	Prof. W. H. Flower, F.R.S.—*Dep. of Anthropol.*, Prof. Huxley, Sec. R.S.—*Dep. of Anat. and Physiol.*, R. McDonnell, M.D., F.R.S.	Dr. R. J. Harvey, Dr. T. Hayden, Prof. W. R. M‘Nab, Prof. J. M. Purser, J. B. Rowe, F. W. Rudler.
1879. Sheffield ...	Prof. St. George Mivart, F.R.S.—*Dep. of Anthropol.*, E. B. Tylor, D.C.L., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Pye-Smith.	Arthur Jackson, Prof. W. R. M‘Nab, J. B. Rowe, F. W. Rudler, Prof. Schäfer.
1880. Swansea ...	A. C. L. Günther, F.R.S.—*Dep. of Anat. & Physiol.*, F. M. Balfour, F.R.S.—*Dep. of Anthropol.*, F. W. Rudler.	G. W. Bloxam, John Priestley, Howard Saunders, Adam Sedgwick.
1881. York.........	R. Owen, F.R.S.—*Dep. of Anthropol.*, Prof. W. H. Flower, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. J. S. Burdon Sanderson, F.R.S.	G. W. Bloxam, W. A. Forbes, Rev. W. C. Hey, Prof. W. R. M‘Nab, W. North, John Priestley, Howard Saunders, H. E. Spencer.
1882. Southampton.	Prof. A. Gamgee, M.D., F.R.S.—*Dep. of Zool. and Bot.*, Prof. M. A. Lawson, F.L.S.—*Dep. of Anthropol.*, Prof. W. Boyd Dawkins, F.R.S.	G. W. Bloxam, W. Heape, J. B. Nias, Howard Saunders, A. Sedgwick, T. W. Shore, jun.
1883. Southport[1]	Prof. E. Ray Lankester, M.A., F.R.S.—*Dep. of Anthropol.*, W. Pengelly, F.R.S.	G. W. Bloxam, Dr. G. J. Haslam, W. Heape, W. Hurst, Prof. A. M. Marshall, Howard Saunders, Dr. G. A. Woods.
1884. Montreal ...	Prof. H. N. Moseley, M.A., F.R.S.	Prof. W. Osler, Howard Saunders, A. Sedgwick, Prof. R. R. Wright.
1885. Aberdeen ...	Prof. W. C. M‘Intosh, M.D., LL.D., F.R.S., F.R.S.E.	W. Heape, J. McGregor-Robertson, J. Duncan Matthews, Howard Saunders, H. Marshall Ward.
1886. Birmingham	W. Carruthers, Pres. L.S., F.R.S., F.G.S.	Prof. T. W. Bridge, W. Heape, Prof. W. Hillhouse, W. L. Sclater, Prof. H. Marshall Ward.

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[1] Anthropology was made a separate Section, see p. lxxi.

Date and Place	Presidents	Secretaries
1887. Manchester	Prof. A. Newton, M.A., F.R.S., F.L.S., V.P.Z.S.	C. Bailey, F. E. Beddard, S. F. Harmer, W. Heape, W. L. Sclater, Prof. H. Marshall Ward.
1888. Bath	W. T. Thiselton-Dyer, C.M.G., F.R.S., F.L.S.	F. E. Beddard, S. F. Harmer, Prof. H. Marshall Ward, W. Gardiner, Prof. W. D. Halliburton.
1889. Newcastle-upon-Tyne	Prof. J. S. Burdon Sanderson, M.A., M.D., F.R.S.	C. Bailey, F. E. Beddard, S. F. Harmer, Prof. T. Oliver, Prof. H. Marshall Ward.
1890. Leeds	Prof. A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S.	S. F. Harmer, Prof. W. A. Herdman, S. J. Hickson, F. W. Oliver, H. Wager, H. Marshall Ward.
1891. Cardiff	Francis Darwin, M.A., M.B., F.R.S., F.L.S.	F. E. Beddard, Prof. W. A. Herdman, Dr. S. J. Hickson, G. Murray, Prof. W. N. Parker, H. Wager.
1892. Edinburgh	Prof. W. Rutherford, M.D., F.R.S., F.R.S.E.	G. Brook, Prof. W. A. Herdman, G. Murray, W. Stirling, H. Wager.
1893. Nottingham[1]	Rev. Canon H. B. Tristram, M.A., LL.D., F.R.S.	G. C. Bourne, J. B. Farmer, Prof. W. A. Herdman, S. J. Hickson, W. B. Ransom, W. L. Sclater.
1894. Oxford[2]	Prof. I. Bayley Balfour, M.A., F.R.S.	W. W. Benham, Prof. J. B. Farmer, Prof. W. A. Herdman, Prof. S. J. Hickson, G. Murray, W. L. Sclater.

SECTION D (*continued*).—ZOOLOGY.

1895. Ipswich	Prof. W. A. Herdman, F.R.S.	G. C. Bourne, H. Brown, W. E. Hoyle, W. L. Sclater.
1896. Liverpool	Prof. E. B. Poulton, F.R.S.	H. O. Forbes, W. Garstang, W. E. Hoyle.
1897. Toronto	Prof. L. C. Miall, F.R.S.	W. Garstang, W. E. Hoyle, Prof. E. E. Prince.
1898. Bristol	Prof. W. F. R. Weldon, F.R.S.	Prof. R. Boyce, W. Garstang, Dr. A. J. Harrison, W. E. Hoyle.
1899. Dover	Adam Sedgwick, F.R.S.	W. Garstang, J. Graham Kerr.
1900. Bradford	Dr. R. H. Traquair, F.R.S.	W. Garstang, J. G. Kerr, T. H. Taylor, Swale Vincent.
1901. Glasgow	Prof. J. Cossar Ewart, F.R.S.	J. G. Kerr, J. Rankin, J. Y. Simpson.
1902. Belfast	Prof. G. B. Howes, F.R.S.	Prof. J. G. Kerr, R. Patterson, J. Y. Simpson.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge	Dr. J. Haviland	Dr. H. J. H. Bond, Mr. G. E. Paget.
1834. Edinburgh	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E (UNTIL 1847).—ANATOMY AND MEDICINE.

1835. Dublin	Dr. J. C. Pritchard	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. P. M. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S.	Dr. G. O. Rees, F. Ryland.
1840. Glasgow	James Watson, M.D.	Dr. J. Brown, Prof. Couper, Prof. Reid.

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[1] Physiology was made a separate Section, see p. lxxii.

[2] The title of Section D was changed to Zoology.

Date and Place	Presidents	Secretaries
	SECTION E.—PHYSIOLOGY.	
1841. Plymouth...	P. M. Roget, M.D., Sec. R.S.	J. Butter, J. Fuge, R. S. Sargent.
1842. Manchester	Edward Holme, M.D., F.L.S.	Dr. Chaytor, Dr. R. S. Sargent.
1843. Cork	Sir James Pitcairn, M.D. ...	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.
1845. Cambridge	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton.	Prof. Owen, M.D., F.R.S. ...	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford[1] ...	Prof. Ogle, M.D., F.R.S.	T. K. Chambers, W. P. Ormerod.
	PHYSIOLOGICAL SUBSECTIONS OF SECTION D.	
1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow ...	Prof. Allen Thomson, F.R.S.	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin......	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds	Sir B. Brodie, Bart., F.R.S.	C. G. Wheelhouse.
1859. Aberdeen...	Prof. Sharpey, M.D., Sec.R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford......	Prof.G.Rolleston,M.D.,F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester	Dr. John Davy, F.R.S.	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge	G. E. Paget, M.D................	G. F. Helm, Dr. Edward Smith.
1863. Newcastle	Prof. Rolleston, M.D., F.R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath.........	Dr. Edward Smith, F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birmingham[2]	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C, p. lviii.]

	ETHNOLOGICAL SUBSECTIONS OF SECTION D.	
1846. Southampton	Dr. J. C. Pritchard	Dr. King.
1847. Oxford	Prof. H. H. Wilson, M.A. ...	Prof. Buckley.
1848. Swansea ...	....	G. Grant Francis.
1849. Birmingham	....	Dr. R. G. Latham.
1850. Edinburgh	Vice-Admiral Sir A. Malcolm	Daniel Wilson.
	SECTION E.—GEOGRAPHY AND ETHNOLOGY.	
1851. Ipswich ...	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast......	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, R. MacAdam, Dr. Norton Shaw.
1853. Hull.........	R. G. Latham, M.D., F.R.S.	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool...	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow ...	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin......	Rev. Dr. J. Henthorn Todd, Pres.R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.
1858. Leeds	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, F. Galton, P. O'Callaghan, Dr. Norton Shaw, T. Wright.

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[1] Sections D and E were incorporated under the name of 'Section D—Zoology and Botany, including Physiology' (see p. lxi). Section E, being then vacant, was assigned in 1851 to Geography.

[2] *Vide* note on page lxii.

Date and Place	Presidents	Secretaries
1859. Aberdeen	Rear-Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Prof. Geddes, Dr. Norton Shaw.
1860. Oxford	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lemprière, Dr. Norton Shaw.
1861. Manchester	John Crawfurd, F.R.S.	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge	Francis Galton, F.R.S.	J.W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir H. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, C. R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, Clements R. Markham, T. Wright.

SECTION E (*continued*).—GEOGRAPHY.

Date and Place	Presidents	Secretaries
1869. Exeter	Sir Bartle Frere, K.C.B., LL.D., F.R.G.S.	H. W. Bates, Clements R. Markham, J. H. Thomas.
1870. Liverpool	Sir R. I. Murchison, Bt., K.C.B., LL.D., D.C.L., F.R.S., F.G.S.	H. W. Bates, David Buxton, Albert J. Mott, Clements R. Markham.
1871. Edinburgh	Colonel Yule, C.B., F.R.G.S.	A. Buchan, A. Keith Johnston, Clements R. Markham, J. H. Thomas.
1872. Brighton	Francis Galton, F.R.S.	H. W. Bates, A. Keith Johnston, Rev. J. Newton, J. H. Thomas.
1873. Bradford	Sir Rutherford Alcock, K.C.B.	H. W. Bates, A. Keith Johnston, Clements R. Markham.
1874. Belfast	Major Wilson, R.E., F.R.S., F.R.G.S.	E. G. Ravenstein, E. C. Rye, J. H. Thomas.
1875. Bristol	Lieut.-General Strachey, R.E., C.S.I., F.R.S., F.R.G.S.	H. W. Bates, E. C. Rye, F. F. Tuckett.
1876. Glasgow	Capt. Evans, C.B., F.R.S.	H. W. Bates, E. C. Rye, R. O. Wood.
1877. Plymouth	Adm. Sir E. Ommanney, C.B.	H. W. Bates, F. E. Fox, E. C. Rye.
1878. Dublin	Prof. Sir C. Wyville Thomson, LL.D., F.R.S., F.R.S.E.	John Coles, E. C. Rye.
1879. Sheffield	Clements R. Markham, C.B., F.R.S., Sec. R.G.S.	H. W. Bates, C. E. D. Black, E. C. Rye.
1880. Swansea	Lieut.-Gen. Sir J. H. Lefroy, C.B., K.C.M.G., R.A., F.R.S.	H. W. Bates, E. C. Rye.
1881. York	Sir J. D. Hooker, K.C.S.I., C.B., F.R.S.	J. W. Barry, H. W. Bates.
1882. Southampton.	Sir R. Temple, Bart., G.C.S.I., F.R.G.S.	E. G. Ravenstein, E. C. Rye.
1883. Southport	Lieut.-Col. H. H. Godwin-Austen, F.R.S.	John Coles, E. G. Ravenstein, E. C. Rye.
1884. Montreal	Gen. Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S., V.P.R.G.S.	Rev. Abbé Laflamme, J. S. O'Halloran, E. G. Ravenstein, J. F. Torrance.
1885. Aberdeen	Gen. J. T. Walker, C.B., R.E., LL.D., F.R.S.	J. S. Keltie, J. S. O'Halloran, E. G. Ravenstein, Rev. G. A. Smith.
1886. Birmingham	Maj.-Gen. Sir. F. J. Goldsmid, K.C.S.I., C.B., F.R.G.S.	F. T. S. Houghton, J. S. Keltie, E. G. Ravenstein.
1887. Manchester	Col. Sir C. Warren, R.E., G.C.M.G., F.R.S., F.R.G.S.	Rev. L. C. Casartelli, J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.

Date and Place	Presidents	Secretaries
1888. Bath	Col. Sir C. W. Wilson, R.E., K.C.B., F.R.S., F.R.G.S.	J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1889. Newcastle-upon-Tyne	Col. Sir F. de Winton, K.C.M.G., C.B., F.R.G.S.	J. S. Keltie, H. J. Mackinder, R. Sulivan, A. Silva White.
1890. Leeds	Lieut.-Col. Sir R. Lambert Playfair, K.C.M.G., F.R.G.S.	A. Barker, John Coles, J. S. Keltie, A. Silva White.
1891. Cardiff	E. G. Ravenstein, F.R.G.S., F.S.S.	John Coles, J. S. Keltie, H. J. Mackinder, A. Silva White, Dr. Yeats.
1892. Edinburgh	Prof. J. Geikie, D.C.L., F.R.S., V.P.R.Scot.G.S.	J. G. Bartholomew, John Coles, J. S. Keltie, A. Silva White.
1893. Nottingham	H. Seebohm, Sec. R.S., F.L.S., F.Z.S.	Col. F. Bailey, John Coles, H. O. Forbes, Dr. H. R. Mill.
1894. Oxford	Capt. W. J. L. Wharton, R.N., F.R.S.	John Coles, W. S. Dalgleish, H. N. Dickson, Dr. H. R. Mill.
1895. Ipswich	H. J. Mackinder, M.A., F.R.G.S.	John Coles, H. N. Dickson, Dr. H. R. Mill, W. A. Taylor.
1896. Liverpool	Major L. Darwin, Sec. R.G.S.	Col. F. Bailey, H. N. Dickson, Dr. H. R. Mill, E. C. DuB. Phillips.
1897. Toronto	J. Scott-Keltie, LL.D.	Col. F. Bailey, Capt. Deville, Dr. H. R. Mill, J. B. Tyrrell.
1898. Bristol	Col. G. Earl Church, F.R.G.S.	H. N. Dickson, Dr. H. R. Mill, H. C. Trapnell.
1899. Dover	Sir John Murray, F.R.S.	H. N. Dickson, Dr. H. O. Forbes, Dr. H. R. Mill.
1900. Bradford	Sir George S. Robertson, K.C.S.I.	H. N. Dickson, E. Heawood, E. R. Wethey.
1901. Glasgow	Dr. H. R. Mill, F.R.G.S.	H. N. Dickson, E. Heawood, G. Sandeman, A. C. Turner.
1902. Belfast	Sir T. H. Holdich, K.C.B.	G. G. Chisholm, E. Heawood, Dr. A. J. Herbertson, Dr. J. A. Lindsay.

STATISTICAL SCIENCE.

COMMITTEE OF SCIENCES, VI.—STATISTICS.

1833. Cambridge	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh	Sir Charles Lemon, Bart.	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol	Sir Chas. Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S.	F. Clarke, R. W. Rawson, Dr. W. C. Tayler.
1840. Glasgow	Lord Sandon, M.P., F.R.S.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth	Lieut.-Col. Sykes, F.R.S.	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester	G. W. Wood, M.P., F.L.S.	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P.	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge	Rt. Hon. the Earl Fitzwilliam	J. Fletcher, Dr. W. Cooke Tayler.
1846. Southampton.	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W C. Tayler, Rev. T. L. Shapcott.
1847. Oxford	Travers Twiss, D.C.L., F.R.S.	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea	J. H. Vivian, M.P., F.R.S.	J. Fletcher, Capt. R. Shortrede.

Date and Place	Presidents	Secretaries
1849 Birmingham	Rt. Hon. Lord Lyttelton......	Dr. Finch, Prof. Hancock, F. P. G. Neison.
1850. Edinburgh	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich ...	Sir John P. Boileau, Bart. ...	J. Fletcher, Prof. Hancock.
1852. Belfast......	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, jun.
1853. Hull	James Heywood, M.P., F.R.S.	Edward Cheshire, W. Newmarch.
1854. Liverpool...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow ...	R. Monckton Milnes, M.P. ...	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

SECTION F (*continued*).—ECONOMIC SCIENCE AND STATISTICS.

Date and Place	Presidents	Secretaries
1856. Cheltenham	Rt. Hon. Lord Stanley, M.P.	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock, W. Newmarch, W. M. Tartt.
1857. Dublin......	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Prof. J. E. T. Rogers.
1861. Manchester	William Newmarch, F.R.S....	David Chadwick, Prof. R. C. Christie, E. Macrory, Prof. J. E. T. Rogers.
1862. Cambridge	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle .	William Tite, M.P., F.R.S. ...	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath	W. Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers............	R. Birkin, jun., Prof. Leone Levi, E. Macrory.
1867. Dundee	M. E. Grant-Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich	Samuel Brown	Rev. W. C. Davie, Prof. Leone Levi.
1869. Exeter	Rt. Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	E. Macrory, F. Purdy, C. T. D. Acland.
1870. Liverpool...	Prof. W. Stanley Jevons, M.A.	Chas. R. Dudley Baxter, E. Macrory, J. Miles Moss.
1871. Edinburgh	Rt. Hon. Lord Neaves	J. G. Fitch, James Meikle.
1872. Brighton ...	Prof. Henry Fawcett, M.P. ...	J. G. Fitch, Barclay Phillips.
1873. Bradford ...	Rt. Hon. W. E. Forster, M.P.	J. G. Fitch, Swire Smith.
1874. Belfast......	Lord O'Hagan	Prof. Donnell, F. P. Fellows, Hans MacMordie.
1875. Bristol	James Heywood, M.A., F.R.S., Pres. S.S.	F. P. Fellows, T. G. P. Hallett, E. Macrory.
1876. Glasgow ...	Sir George Campbell, K.C.S.I., M.P.	A. M'Neel Caird, T. G. P. Hallett, Dr. W. Neilson Hancock, Dr. W. Jack.
1877. Plymouth...	Rt. Hon. the Earl Fortescue	W. F. Collier, P. Hallett, J. T. Pim.
1878. Dublin	Prof. J. K. Ingram, LL.D. ...	W. J. Hancock, C. Molloy, J. T. Pim.
1879. Sheffield ...	G. Shaw Lefevre, M.P., Pres. S.S.	Prof. Adamson, R. E. Leader, C. Molloy.
1880. Swansea ...	G. W. Hastings, M.P.	N. A. Humphreys, C. Molloy.
1881. York.........	Rt. Hon. M. E. Grant-Duff, M.A., F.R.S.	C. Molloy, W. W. Morrell, J. F. Moss.
1882. Southampton.	Rt. Hon. G. Sclater-Booth, M.P., F.R.S.	G. Baden-Powell, Prof. H. S. Foxwell, A. Milnes, C. Molloy.

Date and Place	Presidents	Secretaries
1883. Southport	R. H. Inglis Palgrave, F.R.S.	Rev. W. Cunningham, Prof. H. S. Foxwell, J. N. Keynes, C. Molloy.
1884. Montreal	Sir Richard Temple, Bart., G.C.S.I., C.I.E., F.R.G.S.	Prof. H. S. Foxwell, J. S. McLennan, Prof. J. Watson.
1885. Aberdeen	Prof. H. Sidgwick, LL.D., Litt.D.	Rev. W. Cunningham, Prof. H. S. Foxwell, C. McCombie, J. F. Moss.
1886. Birmingham	J. B. Martin, M.A., F.S.S.	F. F. Barham, Rev. W. Cunningham Prof. H. S. Foxwell, J. F. Moss.
1887. Manchester	Robert Giffen, LL.D., V.P.S.S.	Rev. W. Cunningham, F. Y. Edgeworth, T. H. Elliott, C. Hughes, J. E. C. Munro, G. H. Sargant.
1888. Bath	Rt. Hon. Lord Bramwell, LL.D., F.R.S.	Prof. F. Y. Edgeworth, T. H. Elliott, H. S. Foxwell, L. L. F. R. Price.
1889. Newcastle-upon-Tyne	Prof. F. Y. Edgeworth, M.A., F.S.S.	Rev. Dr. Cunningham, T. H. Elliott, F. B. Jevons, L. L. F. R. Price.
1890. Leeds	Prof. A. Marshall, M.A., F.S.S.	W. A. Brigg, Rev. Dr. Cunningham, T. H. Elliott, Prof. J. E. C. Munro, L. L. F. R. Price.
1891. Cardiff	Prof. W. Cunningham, D.D., D.Sc., F.S.S.	Prof. J. Brough, E. Cannan, Prof. E. C. K. Gonner, H. Ll. Smith, Prof. W. R. Sorley.
1892. Edinburgh	Hon. Sir C. W. Fremantle, K.C.B.	Prof. J. Brough, J. R. Findlay, Prof. E. C. K. Gonner, H. Higgs, L. L. F. R. Price.
1893. Nottingham	Prof. J. S. Nicholson, D.Sc., F.S.S.	Prof. E. C. K. Gonner, H. de B. Gibbins, J. A. H. Green, H. Higgs, L. L. F. R. Price.
1894. Oxford	Prof. C. F. Bastable, M.A., F.S.S.	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1895. Ipswich	L. L. Price, M.A.	E. Cannan, Prof. E. C. K. Gonner, H. Higgs.
1896. Liverpool	Rt. Hon. L. Courtney, M.P.	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1897. Toronto	Prof. E. C. K. Gonner, M.A.	E. Cannan, H. Higgs, Prof. A. Shortt.
1898. Bristol	J. Bonar, M.A., LL.D.	E. Cannan, Prof. A. W. Flux, H. Higgs, W. E. Tanner.
1899. Dover	H. Higgs, LL.B.	A. L. Bowley, E. Cannan, Prof. A. W. Flux, Rev. G. Sarson.
1900. Bradford	Major P. G. Craigie, V.P.S.S.	A. L. Bowley, E. Cannan, S. J. Chapman, F. Hooper.
1901. Glasgow	Sir R. Giffen, K.C.B., F.R.S.	W. W. Blackie, A. L. Bowley, E. Cannan, S. J. Chapman.
1902. Belfast	E. Cannan, M.A., LL.D.	A. L. Bowley, Prof. S. J. Chapman, Dr. A. Duffin.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol	Davies Gilbert, D.C.L., F.R.S.	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle	Charles Babbage, F.R.S.	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S., and Robt. Stephenson.	W. Carpmael, William Hawkes, T. Webster.
1840. Glasgow	Sir John Robinson	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester	Rev. Prof. Willis, F.R.S.	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork	Prof. J. Macneill, M.R.I.A.	James Thomson, Robert Mallet.
1844. York	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge	George Rennie, F.R.S.	Rev. W. T. Kingsley.

Date and Place	Presidents	Secretaries
1846. Southampton	Rev. Prof. Willis, M.A., F.R.S.	William Betts, jun., Charles Manby.
1847. Oxford	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea ...	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robt. Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh	Rev. R. Robinson	Dr. Lees, David Stephenson.
1851. Ipswich ...	William Cubitt, F.R.S..........	John Head, Charles Manby.
1852. Belfast......	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull	William Fairbairn, F.R.S.	J. Oldham, J. Thomson, W. S. Ward.
1854. Liverpool...	John Scott Russell, F.R.S. ...	J. Grantham, J. Oldham, J. Thomson.
1855. Glasgow ...	W. J. M. Rankine, F.R.S. ...	L. Hill, W. Ramsay, J. Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, H. M. Jeffery.
1857. Dublin......	Rt. Hon. the Earl of Rosse, F.R.S.	Prof. Downing, W.T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds	William Fairbairn, F.R.S. ...	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen...	Rev. Prof. Willis, M.A., F.R.S.	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester	J. F. Bateman, C.E., F.R.S....	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge.	William Fairbairn, F.R.S.	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle .	Rev. Prof. Willis, M.A., F.R.S.	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P. Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. O. Tarbotton.
1867. Dundee......	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.
1868. Norwich ...	G. P. Bidder, C.E., F.R.G.S.	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.
1869. Exeter	C. W. Siemens, F.R.S..........	P. Le Neve Foster, H. Bauerman.
1870. Liverpool...	Chas. B. Vignoles, C.E., F.R.S.	H. Bauerman, P. Le Neve Foster, T. King, J. N. Shoolbred.
1871. Edinburgh	Prof. Fleeming Jenkin, F.R.S.	H. Bauerman, A. Leslie, J. P. Smith.
1872. Brighton ...	F. J. Bramwell, C.E.	H. M. Brunel, P. Le Neve Foster, J. G. Gamble, J. N. Shoolbred.
1873. Bradford ...	W. H. Barlow, F.R.S.	C. Barlow, H. Bauerman, E. H. Carbutt, J. C. Hawkshaw, J. N. Shoolbred.
1874. Belfast......	Prof. James Thomson, LL.D., C.E., F.R.S.E.	A. T. Atchison, J. N. Shoolbred, John Smyth, jun.
1875. Bristol	W. Froude, C.E., M.A., F.R.S.	W. R. Browne, H. M. Brunel, J. G. Gamble, J. N. Shoolbred.
1876. Glasgow ...	C. W. Merrifield, F.R.S.	W. Bottomley, jun., W. J. Millar, J. N. Shoolbred, J. P. Smith.
1877. Plymouth...	Edward Woods, C.E.	A. T. Atchison, Dr. Merrifield, J. N. Shoolbred.
1878. Dublin	Edward Easton, C.E.	A. T. Atchison, R. G. Symes, H. T. Wood.
1879. Sheffield ...	J. Robinson, Pres. Inst. Mech. Eng.	A. T. Atchison, Emerson Bainbridge, H. T. Wood.
1880. Swansea ...	J. Abernethy, F.R.S.E..........	A. T. Atchison, H. T. Wood.
1881. York.........	Sir W. G. Armstrong, C.B., LL.D., D.C.L., F.R.S.	A. T. Atchison, J. F. Stephenson, H. T. Wood.
1882. Southampton.	John Fowler, C.E., F.G.S. ...	A. T. Atchison, F. Churton, H. T. Wood.
1883. Southport .	J. Brunlees, Pres. Inst. C.E.	A. T. Atchison, E. Rigg, H. T. Wood.

Date and Place	Presidents	Secretaries
1884. Montreal	Sir F. J. Bramwell, F.R.S., V.P.Inst.C.E.	A. T. Atchison, W. B. Dawson, J. Kennedy, H. T. Wood.
1885. Aberdeen	B. Baker, M.Inst.C.E.	A. T. Atchison, F. G. Ogilvie, E. Rigg, J. N. Shoolbred.
1886 Birmingham	Sir J. N. Douglass, M.Inst. C.E	C. W. Cooke, J. Kenward, W. B. Marshall, E. Rigg.
1887. Manchester	Prof. Osborne Reynolds, M.A., LL.D., F.R.S.	C. F. Budenberg, W. B. Marshall, E. Rigg.
1888. Bath	W. H. Preece, F.R.S., M.Inst.C.E.	C. W. Cooke, W. B. Marshall, E. Rigg, P. K. Stothert.
1889. Newcastle-upon-Tyne	W. Anderson, M.Inst.C.E.	C. W. Cooke, W. B. Marshall, Hon. C. A. Parsons, E. Rigg.
1890. Leeds	Capt. A. Noble, C.B., F.R.S., F.R.A.S.	E. K. Clark, C. W. Cooke, W. B. Marshall, E. Rigg.
1891. Cardiff	T. Forster Brown, M.Inst.C.E.	C. W. Cooke, Prof. A. C. Elliott, W. B. Marshall, E. Rigg.
1892. Edinburgh	Prof. W. C. Unwin, F.R.S., M.Inst.C.E.	C. W. Cooke, W. B. Marshall, W. C. Popplewell, E. Rigg.
1893. Nottingham	Jeremiah Head, M.Inst C.E., F.C.S.	C. W. Cooke, W. B. Marshall, E. Rigg, H. Talbot.
1894. Oxford	Prof. A. B. W. Kennedy, F.R.S., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, Rev. F. J. Smith.
1895. Ipswich	Prof. L. F. Vernon-Harcourt, M.A., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, P. G. M. Stoney.
1896. Liverpool	Sir Douglas Fox, V.P.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, S. Dunkerley, W. B. Marshall.
1897. Toronto	G. F. Deacon, M.Inst.C.E.	Prof. T. Hudson Beare, Prof. Callendar, W. A. Price.
1898. Bristol	Sir J. Wolfe-Barry, K.C.B., F.R.S.	Prof. T. H. Beare, Prof. J. Munro, H. W. Pearson, W. A. Price.
1899. Dover	Sir W. White, K.C.B., F.R.S.	Prof. T. H. Beare, W. A. Price, H. E. Stilgoe.
1900. Bradford	Sir Alex. R. Binnie, M.Inst. C.E.	Prof. T. H. Beare, C. F. Charnock, Prof. S. Dunkerley, W. A. Price.
1901. Glasgow	R. E. Crompton, M.Inst.C.E.	H. Bamford, W. E. Dalby, W. A. Price.
1902. Belfast	Prof. J. Perry, F.R.S.	M. Barr, W. A. Price, J. Wylie.

SECTION H.—ANTHROPOLOGY.

Date and Place	Presidents	Secretaries
1884. Montreal	E. B. Tylor, D.C.L., F.R.S.	G. W. Bloxam, W. Hurst.
1885. Aberdeen	Francis Galton, M.A., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. A. Macgregor.
1886. Birmingham	Sir G. Campbell, K.C.S.I., M.P., D.C.L., F.R.G.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. R. Saundby.
1887. Manchester	Prof. A. H. Sayce, M.A.	G. W. Bloxam, Dr. J. G. Garson, Dr. A. M. Paterson.
1888. Bath	Lieut.-General Pitt-Rivers, D.C.L., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, J. Harris Stone.
1889. Newcastle-upon-Tyne	Prof. Sir W. Turner, M.B., LL.D., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, Dr. R. Morison, Dr. R. Howden.
1890. Leeds	Dr. J. Evans, Treas. R.S., F.S.A., F.L.S., F.G.S.	G. W. Bloxam, Dr. C. M. Chadwick, Dr. J. G. Garson.
1891. Cardiff	Prof. F. Max Müller, M.A.	G. W. Bloxam, Prof. R. Howden, H. Ling Roth, E. Seward.
1892. Edinburgh	Prof. A. Macalister, M.A., M.D., F.R.S.	G. W. Bloxam, Dr. D. Hepburn, Prof. R. Howden, H. Ling Roth.
1893. Nottingham	Dr. R. Munro, M.A., F.R.S.E.	G. W. Bloxam, Rev. T. W. Davies, Prof. R. Howden, F. B. Jevons, J. L. Myres.

Date and Place	Presidents	Secretaries
1894. Oxford......	Sir W. H. Flower, K.C.B., F.R.S.	H. Balfour, Dr. J. G. Garson, H. Ling Roth.
1895. Ipswich ...	Prof. W. M. Flinders Petrie, D.C.L.	J. L. Myres, Rev. J. J. Raven, H. Ling Roth.
1896. Liverpool...	Arthur J. Evans, F.S.A.	Prof. A. C. Haddon, J. L. Myres, Prof. A. M. Paterson.
1897. Toronto ...	Sir W. Turner, F.R.S.	A. F. Chamberlain, H. O. Forbes, Prof. A. C. Haddon, J. L. Myres.
1898. Bristol......	E. W. Brabrook, C.B.	H. Balfour, J. L. Myres, G. Parker.
1899. Dover	C. H. Read, F.S.A.	H. Balfour, W. H. East, Prof. A. C. Haddon, J. L. Myres.
1900. Bradford ...	Prof. John Rhys, M.A.........	Rev. E. Armitage, H. Balfour, W. Crooke, J. L. Myres.
1901. Glasgow ...	Prof. D. J. Cunningham, F.R.S.	W. Crooke, Prof. A. F. Dixon, J. F. Gemmill, J. L. Myres.
1902. Belfast ...	Dr. A. C. Haddon, F.R.S. ...	R. Campbell, Prof. A. F. Dixon, J. L. Myres.

SECTION I.—PHYSIOLOGY (including EXPERIMENTAL PATHOLOGY AND EXPERIMENTAL PSYCHOLOGY).

Date and Place	Presidents	Secretaries
1894. Oxford......	Prof. E. A. Schäfer, F.R.S., M.R.C.S.	Prof. F. Gotch, Dr. J. S. Haldane, M. S. Pembrey.
1896. Liverpool...	Dr. W. H. Gaskell, F.R.S.	Prof. R. Boyce, Prof. C. S. Sherrington.
1897. Toronto ...	Prof. Michael Foster, F.R.S.	Prof. R. Boyce, Prof. C. S. Sherrington, Dr. L. E. Shore.
1899. Dover	J. N. Langley, F.R.S.	Dr. Howden, Dr. L. E. Shore, Dr. E. H. Starling.
1901. Glasgow ...	Prof. J. G. McKendrick.	W. B. Brodie, W. A. Osborne, Prof. W. H. Thompson.
1902. Belfast ...	Prof. W. D. Halliburton, F.R.S.	J. Barcroft, Dr. W. A. Osborne, Dr. C. Shaw.

SECTION K.—BOTANY.

Date and Place	Presidents	Secretaries
1895. Ipswich ...	W. T. Thiselton-Dyer, F.R.S.	A. C. Seward, Prof. F. E. Weiss.
1896. Liverpool...	Dr. D. H. Scott, F.R.S.	Prof. Harvey Gibson, A. C. Seward, Prof. F. E. Weiss.
1897. Toronto ...	Prof. Marshall Ward, F.R.S.	Prof. J. B. Farmer, E. C. Jeffrey, A. C. Seward, Prof. F. E. Weiss.
1898. Bristol	Prof. F. O. Bower, F.R.S. ...	A. C. Seward, H. Wager, J. W. White.
1899. Dover	Sir George King, F.R.S.	G. Dowker, A. C. Seward, H. Wager
1900. Bradford ...	Prof. S. H. Vines, F.R.S.......	A. C. Seward, H. Wager, W. West.
1901. Glasgow ...	Prof. I. B. Balfour, F.R.S. ...	D. T. Gwynne-Vaughan, G. F. Scott-Elliot, A. C. Seward, H. Wager.
1902. Belfast ...	Prof. J. R. Green, F.R.S.......	A. G. Tansley, Rev. C. H. Waddell, H. Wager, R. H. Yapp.

SECTION L.—EDUCATIONAL SCIENCE.

Date and Place	Presidents	Secretaries
1901. Glasgow ...	Sir John E. Gorst, F.R.S. ...	R. A. Gregory, W. M. Heller, R. Y. Howie, C. W. Kimmins, Prof. H. L. Withers.
1902. Belfast ...	Prof. H. E. Armstrong, F.R.S.	Prof. R. A. Gregory, W. M. Heller, R. M. Jones, Dr. C. W. Kimmins, Prof. H. L. Withers.

LIST OF EVENING DISCOURSES.

Date and Place	Lecturer	Subject of Discourse
1842. Manchester	Charles Vignoles, F.R.S.	The Principles and Construction of Atmospheric Railways.
	Sir M. I. Brunel	The Thames Tunnel.
	R. I. Murchison	The Geology of Russia.
1843. Cork	Prof. Owen, M.D., F.R.S.	The Dinornis of New Zealand.
	Prof. E. Forbes, F.R.S.	The Distribution of Animal Life in the Ægean Sea.
	Dr. Robinson	The Earl of Rosse's Telescope.
1844. York	Charles Lyell, F.R.S.	Geology of North America.
	Dr. Falconer, F.R.S.	The Gigantic Tortoise of the Siwalik Hills in India.
1845. Cambridge	G.B.Airy, F.R.S., Astron. Royal	Progress of Terrestrial Magnetism.
	R. I. Murchison, F.R.S.	Geology of Russia.
1846. Southampton.	Prof. Owen, M.D., F.R.S.	Fossil Mammalia of the British Isles.
	Charles Lyell, F.R.S.	Valley and Delta of the Mississippi.
	W. R. Grove, F.R.S.	Properties of the Explosive Substance discovered by Dr. Schönbein; also some Researches of his own on the Decomposition of Water by Heat.
1847. Oxford	Rev. Prof. B. Powell, F.R.S.	Shooting Stars.
	Prof. M. Faraday, F.R.S.	Magnetic and Diamagnetic Phenomena.
	Hugh E. Strickland, F.G.S.	The Dodo (*Didus ineptus*).
1848. Swansea	John Percy, M.D., F.R.S.	Metallurgical Operations of Swansea and its Neighbourhood.
	W. Carpenter, M.D., F.R.S.	Recent Microscopical Discoveries.
1849. Birmingham	Dr. Faraday, F.R.S.	Mr. Gassiot's Battery.
	Rev. Prof. Willis, M.A., F.R.S.	Transit of different Weights with varying Velocities on Railways.
1850. Edinburgh	Prof. J. H. Bennett, M.D., F.R.S.E.	Passage of the Blood through the minute vessels of Animals in connection with Nutrition.
	Dr. Mantell, F.R.S.	Extinct Birds of New Zealand.
1851. Ipswich	Prof. R. Owen, M.D., F.R.S.	Distinction between Plants and Animals, and their changes of Form.
	G.B.Airy, F.R.S., Astron. Royal	Total Solar Eclipse of July 28, 1851.
1852. Belfast	Prof. G. G. Stokes, D.C.L., F.R.S.	Recent Discoveries in the properties of Light.
	Colonel Portlock, R.E., F.R.S.	Recent Discovery of Rock-salt at Carrickfergus, and geological and practical considerations connected with it.
1853. Hull	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	Some peculiar Phenomena in the Geology and Physical Geography of Yorkshire.
	Robert Hunt, F.R.S.	The present state of Photography.
1854. Liverpool	Prof. R. Owen, M.D., F.R.S.	Anthropomorphous Apes.
	Col. E. Sabine, V.P.R.S.	Progress of Researches in Terrestrial Magnetism.
1855. Glasgow	Dr. W. B. Carpenter, F.R.S.	Characters of Species.
	Lieut.-Col. H. Rawlinson	Assyrian and Babylonian Antiquities and Ethnology.
1856. Cheltenham	Col. Sir H. Rawlinson	Recent Discoveries in Assyria and Babylonia, with the results of Cuneiform Research up to the present time.
	W. R. Grove, F.R.S.	Correlation of Physical Forces.

Date and Place	Lecturer	Subject of Discourse
1857. Dublin......	Prof. W. Thomson, F.R.S. ...	The Atlantic Telegraph.
	Rev. Dr. Livingstone, D.C.L.	Recent Discoveries in Africa.
1858. Leeds	Prof. J. Phillips, LL.D., F.R.S.	The Ironstones of Yorkshire.
	Prof. R. Owen, M.D., F.R.S.	The Fossil Mammalia of Australia.
1859. Aberdeen...	Sir R. I. Murchison, D.C.L....	Geology of the Northern Highlands.
	Rev. Dr. Robinson, F.R.S. ...	Electrical Discharges in highly rarefied Media.
1860. Oxford......	Rev. Prof. Walker, F.R.S. ...	Physical Constitution of the Sun.
	Captain Sherard Osborn, R.N.	Arctic Discovery.
1861. Manchester	Prof. W. A. Miller, M.A., F.R.S.	Spectrum Analysis.
	G. B. Airy, F.R.S., Astron. Royal.	The late Eclipse of the Sun.
1862. Cambridge	Prof. Tyndall, LL.D., F.R.S.	The Forms and Action of Water.
	Prof. Odling, F.R.S............	Organic Chemistry.
1863. Newcastle	Prof. Williamson, F.R.S......	The Chemistry of the Galvanic Battery considered in relation to Dynamics.
	James Glaisher, F.R.S.........	The Balloon Ascents made for the British Association.
1864. Bath.........	Prof. Roscoe, F.R.S.............	The Chemical Action of Light.
	Dr. Livingstone, F.R.S.	Recent Travels in Africa.
1865. Birmingham	J. Beete Jukes, F.R.S.........	Probabilities as to the position and extent of the Coal-measures beneath the red rocks of the Midland Counties.
1866. Nottingham	William Huggins, F.R.S.......	The results of Spectrum Analysis applied to Heavenly Bodies.
	Dr. J. D. Hooker, F.R.S.......	Insular Floras.
1867. Dundee......	Archibald Geikie, F.R.S......	The Geological Origin of the present Scenery of Scotland.
	Alexander Herschel, F.R.A.S.	The present state of Knowledge regarding Meteors and Meteorites.
1868. Norwich ...	J. Fergusson, F.R.S............	Archæology of the early Buddhist Monuments.
	Dr. W. Odling, F.R.S.	Reverse Chemical Actions.
1869. Exeter	Prof. J. Phillips, LL.D., F.R.S.	Vesuvius.
	J. Norman Lockyer, F.R.S. ..	The Physical Constitution of the Stars and Nebulæ.
1870. Liverpool...	Prof. J. Tyndall, LL.D., F.R.S.	The Scientific Use of the Imagination.
	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	Stream-lines and Waves, in connection with Naval Architecture.
1871. Edinburgh	F. A. Abel, F.R.S...............	Some Recent Investigations and Applications of Explosive Agents.
	E. B. Tylor, F.R.S.	The Relation of Primitive to Modern Civilisation.
1872. Brighton ...	Prof. P. Martin Duncan, M.B., F.R.S.	Insect Metamorphosis.
	Prof. W. K. Clifford	The Aims and Instruments of Scientific Thought.
1873. Bradford ...	Prof. W. C. Williamson, F.R.S.	Coal and Coal Plants.
	Prof. Clerk Maxwell, F.R.S.	Molecules.
1874. Belfast......	Sir John Lubbock, Bart., M.P., F.R.S.	Common Wild Flowers considered in relation to Insects.
	Prof. Huxley, F.R.S.	The Hypothesis that Animals are Automata, and its History.
1875. Bristol	W. Spottiswoode, LL.D., F.R.S.	The Colours of Polarised Light.
	F. J. Bramwell, F.R.S..........	Railway Safety Appliances.
1876. Glasgow ...	Prof. Tait, F.R.S.E.	Force.
	Sir Wyville Thomson, F.R.S.	The 'Challenger' Expedition.

Date and Place	Lecturer	Subject of Discourse
1877. Plymouth	W. Warington Smyth, M.A., F.R.S.	Physical Phenomena connected with the Mines of Cornwall and Devon.
	Prof. Odling, F.R.S.	The New Element, Gallium.
1878. Dublin	G. J. Romanes, F.L.S.	Animal Intelligence.
	Prof. Dewar, F.R.S.	Dissociation, or Modern Ideas of Chemical Action.
1879. Sheffield	W. Crookes, F.R.S.	Radiant Matter.
	Prof. E. Ray Lankester, F.R.S.	Degeneration.
1880. Swansea	Prof. W. Boyd Dawkins, F.R.S.	Primeval Man.
	Francis Galton, F.R.S.	Mental Imagery.
1881. York	Prof. Huxley, Sec. R.S.	The Rise and Progress of Palæontology.
	W. Spottiswoode, Pres. R.S.	The Electric Discharge, its Forms and its Functions.
1882. Southampton.	Prof. Sir Wm. Thomson, F.R.S.	Tides.
	Prof. H. N. Moseley, F.R.S.	Pelagic Life.
1883. Southport	Prof. R. S. Ball, F.R.S.	Recent Researches on the Distance of the Sun.
	Prof. J. G. McKendrick.	Galvanic and Animal Electricity.
1884. Montreal	Prof. O. J. Lodge, D.Sc.	Dust.
	Rev. W. H. Dallinger, F.R.S.	The Modern Microscope in Researches on the Least and Lowest Forms of Life.
1885. Aberdeen	Prof. W. G. Adams, F.R.S.	The Electric Light and Atmospheric Absorption.
	John Murray, F.R.S.E.	The Great Ocean Basins.
1886. Birmingham	A. W. Rücker, M.A., F.R.S.	Soap Bubbles.
	Prof. W. Rutherford, M.D.	The Sense of Hearing.
1887. Manchester	Prof. H. B. Dixon, F.R.S.	The Rate of Explosions in Gases.
	Col. Sir F. de Winton	Explorations in Central Africa.
1888. Bath	Prof. W. E. Ayrton, F.R.S.	The Electrical Transmission of Power.
	Prof. T. G. Bonney, D.Sc., F.R.S.	The Foundation Stones of the Earth's Crust.
1889. Newcastle-upon-Tyne	Prof. W. C. Roberts-Austen, F.R.S.	The Hardening and Tempering of Steel.
	Walter Gardiner, M.A.	How Plants maintain themselves in the Struggle for Existence.
1890. Leeds	E. B. Poulton, M.A., F.R.S.	Mimicry.
	Prof. C. Vernon Boys, F.R.S.	Quartz Fibres and their Applications.
1891. Cardiff	Prof. L. C. Miall, F.L.S., F.G.S.	Some Difficulties in the Life of Aquatic Insects.
	Prof. A. W. Rücker, M.A., F.R.S.	Electrical Stress.
1892. Edinburgh	Prof. A. M. Marshall, F.R.S.	Pedigrees.
	Prof. J. A. Ewing, M.A., F.R.S.	Magnetic Induction.
1893. Nottingham	Prof. A. Smithells, B.Sc.	Flame.
	Prof. Victor Horsley, F.R.S.	The Discovery of the Physiology of the Nervous System.
1894. Oxford	J. W. Gregory, D.Sc., F.G.S.	Experiences and Prospects of African Exploration.
	Prof. J. Shield Nicholson, M.A.	Historical Progress and Ideal Socialism.
1895. Ipswich	Prof. S. P. Thompson, F.R.S.	Magnetism in Rotation.
	Prof. Percy F. Frankland, F.R.S.	The Work of Pasteur and its various Developments.
1896. Liverpool	Dr. F. Elgar, F.R.S.	Safety in Ships.
	Prof. Flinders Petrie, D.C.L.	Man before Writing.
1897. Toronto	Prof. W. C. Roberts-Austen, F.R.S.	Canada's Metals.
	J. Milne, F.R.S.	Earthquakes and Volcanoes.

Date and Place	Lecturer	Subject of Discourse
1898. Bristol......	Prof. W. J. Sollas, F.R.S. ...	Funafuti: the Study of a Coral Island.
	Herbert Jackson	Phosphorescence.
1899. Dover	Prof. Charles Richet...........	La vibration nerveuse.
	Prof. J. Fleming, F.R.S.	The Centenary of the Electric Current.
1900. Bradford ...	Prof. F. Gotch, F.R.S.	Animal Electricity.
	Prof. W. Stroud.	Range Finders.
1901. Glasgow ...	Prof. W. Ramsay, F.R.S.	The Inert Constituents of the Atmosphere.
	F. Darwin, F.R.S.	The Movements of Plants.
1902. Belfast ...	Prof. J. J. Thomson, F.R.S....	Becquerel Rays and Radio-activity.
	Prof. W. F. R. Weldon, F.R.S.	Inheritance.

LECTURES TO THE OPERATIVE CLASSES.

Date and Place	Lecturer	Subject of Discourse
1867. Dundee......	Prof. J. Tyndall, LL.D., F.R.S.	Matter and Force.
1868. Norwich ...	Prof. Huxley, LL.D., F.R.S.	A Piece of Chalk.
1869. Exeter	Prof. Miller, M.D., F.R.S. ...	The modes of detecting the Composition of the Sun and other Heavenly Bodies by the Spectrum.
1870. Liverpool...	Sir John Lubbock, Bart., F.R.S.	Savages.
1872. Brighton ...	W. Spottiswoode, LL.D., F.R.S.	Sunshine, Sea, and Sky.
1873. Bradford ...	C. W. Siemens, D.C.L., F.R.S.	Fuel.
1874. Belfast	Prof. Odling, F.R.S.............	The Discovery of Oxygen.
1875. Bristol	Dr. W. B. Carpenter, F.R.S.	A Piece of Limestone.
1876. Glasgow ...	Commander Cameron, C.B....	A Journey through Africa.
1877. Plymouth...	W. H. Preece	Telegraphy and the Telephone.
1879. Sheffield ...	W. E. Ayrton	Electricity as a Motive Power.
1880. Swansea ...	H. Seebohm, F.Z.S.	The North-East Passage.
1881. York	Prof. Osborne Reynolds, F.R.S.	Raindrops, Hailstones, and Snowflakes.
1882. Southampton.	John Evans, D.C.L., Treas. R.S.	Unwritten History, and how to read it.
1883. Southport	Sir F. J. Bramwell, F.R.S. ...	Talking by Electricity—Telephones.
1884. Montreal ...	Prof. R. S. Ball, F.R.S.........	Comets.
1885. Aberdeen ...	H. B. Dixon, M.A.	The Nature of Explosions.
1886. Birmingham	Prof. W. C. Roberts-Austen, F.R.S.	The Colours of Metals and their Alloys.
1887. Manchester	Prof. G. Forbes, F.R.S.	Electric Lighting.
1888. Bath	Sir John Lubbock, Bart., F.R.S.	The Customs of Savage Races.
1889. Newcastle-upon-Tyne	B. Baker, M.Inst.C.E.	The Forth Bridge.
1890. Leeds	Prof. J. Perry, D.Sc., F.R.S.	Spinning Tops.
1891. Cardiff	Prof. S. P. Thompson, F.R.S.	Electricity in Mining.
1892. Edinburgh	Prof. C. Vernon Boys, F.R.S.	Electric Spark Photographs.
1893. Nottingham	Prof. Vivian B. Lewes	Spontaneous Combustion.
1894. Oxford	Prof. W. J. Sollas, F.R.S. ...	Geologies and Deluges.
1895. Ipswich ...	Dr. A. H. Fison	Colour.
1896. Liverpool...	Prof. J. A. Fleming, F.R.S....	The Earth a Great Magnet.
1897. Toronto ...	Dr. H. O. Forbes	New Guinea.
1898. Bristol......	Prof. E. B. Poulton, F.R.S.	The ways in which Animals Warn their enemies and Signal to their friends.
1900. Bradford ...	Prof. S. P. Thompson, F.R.S.	Electricity in the Industries.
1901. Glasgow ...	H. J. Mackinder, M.A..........	The Movements of Men by Land and Sea.
1902. Belfast ...	Prof. L. C. Miall, F.R.S.	Gnats and Mosquitoes.

OFFICERS OF SECTIONAL COMMITTEES PRESENT AT THE BELFAST MEETING.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

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Vice-Presidents.—Prof. A. C. Dixon; Prof. J. D. Everett, F.R.S.; Prof. A. R. Forsyth, F.R.S.; Principal E. H. Griffiths, F.R.S.; Dr. Joseph Larmor, Sec.R.S.; Lord Rayleigh, F.R.S.; Principal Sir A. W. Rücker, F.R.S.; Prof. A. Schuster, F.R.S.; Prof. H. H. Turner, F.R.S.

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Secretaries.—Prof. R. A. Gregory; W. M. Heller (*Recorder*); R. M. Jones; Dr. C. W. Kimmins; Prof. H. L. Withers.

COMMITTEE OF RECOMMENDATIONS.

The President and Vice-Presidents of the Meeting; the Presidents of former years; the Trustees; the General and Assistant General Secretaries; the General Treasurer; the Presidents of the Sections; Prof. A. R. Forsyth; Prof. Schuster; Prof. Pope; Prof. Letts; Prof. J. Joly; J. Milne; Prof. Poulton; W. E. Hoyle; Dr. H. R. Mill; Dr. J. Scott Keltie; Sir C. W. Fremantle; E. W. Brabrook; Colonel Crompton; Prof. FitzGerald; H. Balfour; Prof. F. Gotch; Prof. Symington; Prof. W. H. Thompson; A. C. Seward; H. Wager; W. M. Heller; Prof. Miall; Prof. W. W. Watts.

Dr. THE GENERAL TREASURER'S ACCOUNT,

1901-1902. RECEIPTS.

				£	s.	d.
Balance brought forward				1684	11	1
Life Compositions (including Transfers)				512	0	0
New Annual Members' Subscriptions				298	0	0
Annual Subscriptions				575	0	0
Sale of Associates' Tickets				783	0	0
Sale of Ladies' Tickets				244	0	0
Sale of Publications				146	8	3
Dividend on Consols				168	7	4
Dividend on India 3 per Cents				101	14	0
Interest on Deposits: Bradford District Bank	£47	11	0			
Clydesdale Bank	7	18	2			
				55	9	2
Unexpended Balance of Grant returned by Committee on Anthropological Teaching				3	6	0
				£4571	15	10

Investments.

	£	s.	d.
Consols	6501	10	5
India 3 per Cents	3600	0	0
	£10,101	10	5

G. CAREY FOSTER, *General Treasurer.*

from July 1, 1901, to June 30, 1902. *Cr.*

1901–1902. EXPENDITURE.	£	s.	d.	£	s.	d.
Expenses of Glasgow Meeting, including Printing, Advertising, Payment of Clerks, &c., &c.				176	17	3
Rent and Office Expenses				58	13	7
Salaries				515	0	0
Printing, Binding, &c.				1058	5	1
Contribution to Antarctic Expedition				250	0	0
Payment of Grants made at Glasgow:						
Electrical Standards	40	0	0			
Seismological Observations	35	0	0			
Investigation of the Upper Atmosphere by means of Kites	75	0	0			
Magnetic Observations at Falmouth	80	0	0			
Relation between Absorption Spectra and Organic Substances	20	0	0			
Wave-length Tables	5	0	0			
Life-zones in British Carboniferous Rocks	10	0	0			
Exploration of Irish Caves	45	0	0			
Table at the Zoological Station, Naples	100	0	0			
Index Generum et Specierum Animalium	100	0	0			
Migration of Birds	15	0	0			
Structure of Coral Reefs of Indian Ocean	50	0	0			
Compound Ascidians of the Clyde Area	25	0	0			
Terrestrial Surface Waves	15	0	0			
Legislation regulating Women's Labour	30	0	0			
Small Screw Gauge	20	0	0			
Resistance of Road Vehicles to Traction	50	0	0			
Ethnological Survey of Canada	15	0	0			
Age of Stone Circles	30	0	0			
Exploration in Crete	100	0	0			
Anthropometric Investigation of Native Egyptian Soldiers	15	0	0			
Excavations on the Roman Site at Gelligaer	5	0	0			
Changes in Hæmoglobin	15	0	0			
Work of Mammalian Heart under Influence of Drugs	20	0	0			
Investigation of the Cyanophyceæ	10	0	0			
Reciprocal Influence of Universities and Schools	5	0	0			
Conditions of Health essential to carrying on Work in Schools	2	0	0			
Corresponding Societies Committee	15	0	0			
				947	0	0
				3005	15	11
In hands of General Treasurer:						
At Bank of England, Western Branch	£1596	16	6			
Less Cheques not presented	32	0	0			
	1564	16	6			
Cash in hand	1	3	5			
				1565	19	11
				£4571	15	10

I have examined the above Account with the books and vouchers of the Association, and certify the same to be correct. I have also verified the balance at the Bankers', and have ascertained that the Investments are registered in the names of the Trustees.

W. B. KEEN, *Chartered Accountant*,
3 Church Court, Old Jewry, E.C.
July 25, 1902.

Approved—
L. L. PRICE.
E. W BRABROOK, } *Auditors.*

Table showing the Attendance and Receipts

Date of Meeting	Where held	Presidents	Old Life Members	New Life Members
1831, Sept. 27	York	The Earl Fitzwilliam, D.C.L., F.R.S.	—	—
1832, June 19	Oxford	The Rev. W. Buckland, F.R.S.	—	—
1833, June 25	Cambridge	The Rev. A. Sedgwick, F.R.S.	—	—
1834, Sept. 8	Edinburgh	Sir T. M. Brisbane, D.C.L., F.R.S.	—	—
1835, Aug. 10	Dublin	The Rev. Provost Lloyd, LL.D., F.R.S.	—	—
1836, Aug. 22	Bristol	The Marquis of Lansdowne, F.R.S.	—	—
1837, Sept. 11	Liverpool	The Earl of Burlington, F.R.S.	—	—
1838, Aug. 10	Newcastle-on-Tyne	The Duke of Northumberland, F.R.S.	—	—
1839, Aug. 26	Birmingham	The Rev. W. Vernon Harcourt, F.R.S.	—	—
1840, Sept. 17	Glasgow	The Marquis of Breadalbane, F.R.S.	—	—
1841, July 20	Plymouth	The Rev. W. Whewell, F.R.S.	169	65
1842, June 23	Manchester	The Lord Francis Egerton, F.G.S	303	169
1843, Aug. 17	Cork	The Earl of Rosse, F.R.S.	109	28
1844, Sept. 26	York	The Rev. G. Peacock, D.D., F.R.S.	226	150
1845, June 19	Cambridge	Sir John F. W. Herschel, Bart., F.R.S.	313	36
1846, Sept. 10	Southampton	Sir Roderick I. Murchison, Bart., F.R.S.	241	10
1847, June 23	Oxford	Sir Robert H. Inglis, Bart., F.R.S.	314	18
1848, Aug. 9	Swansea	The Marquis of Northampton, Pres. R.S.	149	3
1849, Sept. 12	Birmingham	The Rev. T. R. Robinson, D.D., F.R.S.	227	12
1850, July 21	Edinburgh	Sir David Brewster, K.H., F.R.S.	235	9
1851, July 2	Ipswich	G. B. Airy, Astronomer Royal, F.R.S.	172	8
1852, Sept. 1	Belfast	Lieut.-General Sabine, F.R.S.	164	10
1853, Sept. 3	Hull	William Hopkins, F.R.S.	141	13
1854, Sept. 20	Liverpool	The Earl of Harrowby, F.R.S.	238	23
1855, Sept. 12	Glasgow	The Duke of Argyll, F.R.S.	194	33
1856, Aug. 6	Cheltenham	Prof. C. G. B. Daubeny, M.D., F.R.S.	182	14
1857, Aug. 26	Dublin	The Rev. H. Lloyd, D.D., F.R.S.	236	15
1858, Sept. 22	Leeds	Richard Owen, M.D., D.C.L., F.R.S.	222	42
1859, Sept. 14	Aberdeen	H.R.H. The Prince Consort	184	27
1860, June 27	Oxford	The Lord Wrottesley, M.A., F.R.S.	286	21
1861, Sept. 4	Manchester	William Fairbairn, LL.D., F.R.S.	321	113
1862, Oct. 1	Cambridge	The Rev. Professor Willis, M.A., F.R.S.	239	15
1863, Aug. 26	Newcastle-on-Tyne	Sir William G. Armstrong, C.B., F.R.S.	203	36
1864, Sept. 13	Bath	Sir Charles Lyell, Bart., M.A., F.R.S.	287	40
1865, Sept. 6	Birmingham	Prof. J. Phillips, M.A., LL.D., F.R.S.	292	44
1866, Aug. 22	Nottingham	William R. Grove, Q.C., F.R.S.	207	31
1867, Sept. 4	Dundee	The Duke of Buccleuch, K.C.B., F.R.S.	167	25
1868, Aug. 19	Norwich	Dr. Joseph D. Hooker, F.R.S.	196	18
1869, Aug. 18	Exeter	Prof. G. G. Stokes, D.C.L., F.R.S.	204	21
1870, Sept. 14	Liverpool	Prof. T. H. Huxley, LL.D., F.R.S.	314	39
1871, Aug. 2	Edinburgh	Prof. Sir W. Thomson, LL.D., F.R.S.	246	28
1872, Aug. 14	Brighton	Dr. W. B. Carpenter, F.R.S.	245	36
1873, Sept. 17	Bradford	Prof. A. W. Williamson, F.R.S.	212	27
1874, Aug. 19	Belfast	Prof. J. Tyndall, LL.D., F.R.S.	162	13
1875, Aug. 25	Bristol	Sir John Hawkshaw, F.R.S.	239	36
1876, Sept. 6	Glasgow	Prof. T. Andrews, M.D., F.R.S.	221	35
1877, Aug. 15	Plymouth	Prof. A. Thomson, M.D., F.R.S.	173	19
1878, Aug. 14	Dublin	W. Spottiswoode, M.A., F.R.S.	201	18
1879, Aug. 20	Sheffield	Prof. G. J. Allman, M.D., F.R.S.	184	16
1880, Aug. 25	Swansea	A. C. Ramsay, LL.D., F.R.S.	144	11
1881, Aug. 31	York	Sir John Lubbock, Bart., F.R.S.	272	28
1882, Aug. 23	Southampton	Dr. C. W. Siemens F.R.S.	178	17
1883, Sept. 19	Southport	Prof. A. Cayley, D.C.L., F.R.S.	203	60
1884, Aug. 27	Montreal	Prof. Lord Rayleigh, F.R.S.	235	20
1885, Sept. 9	Aberdeen	Sir Lyon Playfair, K.C.B., F.R.S.	225	18
1886, Sept. 1	Birmingham	Sir J. W. Dawson, C.M.G., F.R.S.	314	25
1887, Aug. 31	Manchester	Sir H. E. Roscoe, D.C.L., F.R.S.	428	86
1888, Sept. 5	Bath	Sir F. J. Bramwell, F.R.S.	266	36
1889, Sept. 11	Newcastle-on-Tyne	Prof. W. H. Flower, C.B., F.R.S.	277	20
1890, Sept. 3	Leeds	Sir F. A. Abel, C.B., F.R.S.	259	21
1891, Aug. 19	Cardiff	Dr. W. Huggins, F.R.S.	189	24
1892, Aug. 3	Edinburgh	Sir A. Geikie, LL.D., F.R.S.	280	14
1893, Sept. 13	Nottingham	Prof. J. S. Burdon Sanderson, F.R.S.	201	17
1894, Aug. 8	Oxford	The Marquis of Salisbury, K.G., F.R.S.	327	21
1895, Sept. 11	Ipswich	Sir Douglas Galton, K.C.B., F.R.S.	214	13
1896, Sept. 16	Liverpool	Sir Joseph Lister, Bart., Pres. R.S.	330	31
1897, Aug. 18	Toronto	Sir John Evans, K.C.B., F.R.S.	120	8
1898, Sept. 7	Bristol	Sir W. Crookes, F.R.S.	281	19
1899, Sept. 13	Dover	Sir Michael Foster, K.C.B., Sec.R.S.	296	20
1900, Sept. 5	Bradford	Sir William Turner, D.C.L., F.R.S.	267	13
1901, Sept. 11	Glasgow	Prof. A. W. Rücker, D.Sc., Sec.R.S.	310	37
1902, Sept. 10	Belfast	Prof. J. Dewar, LL.D., F.R.S.	243	21

*** Ladies were not admitted by purchased tickets until 1843. † Tickets of Admission to Sections only.**

at Annual Meetings of the Association.

Old Annual Members	New Annual Members	Associates	Ladies	Foreigners	Total	Amount received during the Meeting	Grants for Scientific Purposes	Year
—	—	—	—	—	353	—	—	1831
—	—	—	—	—	—	—	—	1832
—	—	—	—	—	900	—	—	1833
—	—	—	—	—	1298	—	£20 0 0	1834
—	—	—	—	—	—	—	167 0 0	1835
—	—	—	—	—	1350	—	435 0 0	1836
—	—	—	—	—	1840	—	922 12 6	1837
—	—	—	1100*	—	2400	—	932 2 2	1838
—	—	—	—	34	1438	—	1595 11 0	1839
—	—	—	—	40	1353	—	1546 16 4	1840
46	317	—	60*	—	891	—	1235 10 11	1841
75	376	33†	331*	28	1315	—	1449 17 8	1842
71	185	—	160	—	—	—	1565 10 2	1843
45	190	9†	260	—	—	—	981 12 8	1844
94	22	407	172	35	1079	—	831 9 9	1845
65	39	270	196	36	857	—	685 16 0	1846
197	40	495	203	53	1320	—	208 5 4	1847
54	25	376	197	15	819	£707 0 0	275 1 8	1848
93	33	447	237	22	1071	963 0 0	159 19 6	1849
128	42	510	273	44	1241	1085 0 0	345 18 0	1850
61	47	244	141	37	710	620 0 0	391 9 7	1851
63	60	510	292	9	1108	1085 0 0	304 6 7	1852
56	57	367	236	6	876	903 0 0	205 0 0	1853
121	121	765	524	10	1802	1882 0 0	380 19 7	1854
142	101	1094	543	26	2133	2311 0 0	480 16 4	1855
104	48	412	346	9	1115	1098 0 0	734 13 9	1856
156	120	900	569	26	2022	2015 0 0	507 15 4	1857
111	91	710	509	13	1698	1931 0 0	618 18 2	1858
125	179	1206	821	22	2564	2782 0 0	684 11 1	1859
177	59	636	463	47	1689	1604 0 0	766 19 6	1860
184	125	1589	791	15	3138	3944 0 0	1111 5 10	1861
150	57	433	242	25	1161	1089 0 0	1293 16 6	1862
154	209	1704	1004	25	3335	3640 0 0	1608 3 10	1863
182	103	1119	1058	13	2802	2965 0 0	1289 15 8	1864
215	149	766	508	23	1997	2227 0 0	1591 7 10	1865
218	105	960	771	11	2303	2469 0 0	1750 13 4	1866
193	118	1163	771	7	2444	2613 0 0	1739 4 0	1867
226	117	720	682	45‡	2004	2042 0 0	1940 0 0	1868
229	107	678	600	17	1856	1931 0 0	1622 0 0	1869
303	195	1103	910	14	2878	3096 0 0	1572 0 0	1870
311	127	976	754	21	2463	2575 0 0	1472 2 6	1871
280	80	937	912	43	2533	2649 0 0	1285 0 0	1872
237	99	796	601	11	1983	2120 0 0	1685 0 0	1873
232	85	817	630	12	1951	1979 0 0	1151 16 0	1874
307	93	884	672	17	2248	2397 0 0	960 0 0	1875
331	185	1265	712	25	2774	3023 0 0	1092 4 2	1876
238	59	446	283	11	1229	1268 0 0	1128 9 7	1877
290	93	1285	674	17	2578	2615 0 0	725 16 6	1878
239	74	529	349	13	1404	1425 0 0	1080 11 11	1879
171	41	389	147	12	915	899 0 0	731 7 7	1880
313	176	1230	514	24	2557	2689 0 0	476 8 1	1881
253	79	516	189	21	1253	1286 0 0	1126 1 11	1882
330	323	952	841	5	2714	3369 0 0	1083 3 3	1883
317	219	826	74	26 & 60 H.§	1777	1855 0 0	1173 4 0	1884
332	122	1053	447	6	2203	2256 0 0	1385 0 0	1885
428	179	1067	429	11	2453	2532 0 0	995 0 6	1886
510	244	1985	493	92	3838	4336 0 0	1186 18 0	1887
399	100	639	509	12	1984	2107 0 0	1511 0 5	1888
412	113	1024	579	21	2437	2441 0 0	1417 0 11	1889
368	92	680	334	12	1775	1776 0 0	789 16 8	1890
341	152	672	107	35	1497	1664 0 0	1029 10 0	1891
413	141	733	439	50	2070	2007 0 0	864 10 0	1892
328	57	773	268	17	1661	1653 0 0	907 15 6	1893
435	69	941	451	77	2321	2175 0 0	583 15 6	1894
290	31	493	261	22	1324	1236 0 0	977 15 5	1895
383	139	1384	873	41	3181	3228 0 0	1104 6 1	1896
286	125	682	100	41	1362	1398 0 0	1059 10 8	1897
327	96	1051	639	33	2446	2399 0 0	1212 0 0	1898
324	68	548	120	27	1403	1328 0 0	1430 14 2	1899
297	45	801	482	9	1915	1801 0 0	1072 10 0	1900
374	131	794	246	20	1912	2046 0 0	945 0 0	1901
314	86	647	305	6	1620	1644 0 0	947 0 0	1902

‡ Including Ladies. § Fellows of the American Association were admitted as Hon. Members for this Meeting.

OFFICERS AND COUNCIL, 1902–1903.

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The Trustees, the President and President Elect, the Presidents of former years, the Vice-Presidents and Vice-Presidents Elect, the General and Assistant General Secretaries for the present and former years, the General Treasurers for the present and former years, and the Local Treasurer and Secretaries for the ensuing Meeting.

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The Right Hon. Lord RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S.
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AUDITORS.

E. W. Brabrook, Esq. C.B.
L. L. Price, Esq., M.A.

Report of the Council for the Year 1901–1902, *presented to the General Committee at Belfast on Wednesday, September* 10, 1902.

The first paragraph in the Report of the Council must this year be a sad one. For many years the late Mr. George Griffith, Assistant General Secretary, had been one of the most prominent figures at the Meetings of the Association. He brought to his work as Secretary stores of wide learning, unwearying energy, and a power of personal attraction which won him many friends. His sudden death has deprived the Association of the services of a devoted officer who will be long and sorely missed by many who knew his worth and can sympathise with his sorrowing family. At its first meeting after the death of Mr. Griffith the Council passed a resolution expressing their sorrow and their sympathy with Mrs. Griffith and her children.

The Council have nominated Dr. J. G. Garson, who has had great experience in the work of the Association, for appointment as Assistant General Secretary in succession to Mr. Griffith.

The Council have received Reports from the General Treasurer during the past year, and his accounts from July 1, 1901, to June 30, 1902, duly audited, are presented to the General Committee.

The Council heard with great regret of the death of the Marquess of Dufferin and Ava, one of the Vice-Presidents for the Belfast meeting. The Rev. Dr. Salmon, who was also nominated a Vice-President, was unable to accept the office, as he was not likely to attend the meeting. The Council have nominated the Duke of Abercorn a Vice-President for the Belfast meeting.

The Council, having been informed by Sir William Roberts-Austen that he does not intend to offer himself for re-election as General Secretary after the Belfast Meeting, desire to record their sense of the valuable services which he has rendered to the Association. He has twice accompanied the Association to Canada, and at the Toronto meeting acted for the first time as General Secretary.

The Council recommend that Major P. A. MacMahon, D.Sc., F.R.S., be appointed General Secretary in succession to Sir William Roberts-Austen.

The Council have elected Professor H. Elster and Professor J. Geitel, who have attended meetings of the Association, Corresponding Members.

The Council, having received an invitation to appoint a representative to attend the Jubilee of the Owens College, Manchester, on March 12, 1902, requested the President, the Treasurer, and one of the General Secretaries to attend the celebration and to present the following Address:—

'BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

'The Council of the British Association for the Advancement of Science desire to offer their hearty congratulations to the Owens College, Manchester, on the Jubilee of the foundation of that Institution. The work which has been done in Manchester in the last half-century has left a mark, not only on that city, but on the educational system of the entire kingdom. The British Association gladly unite themselves with those who honour the parent College of the Victoria University, and cannot forget that the energy and ability of Manchester caused the Meeting of the Association held in that city under the Presidency of Sir Henry Roscoe to be the largest of all the Meetings which the Association has held. It is their sincere desire that the success of the College may be as marked, and that the ties which bind it to the British Association may be as close in the future as they have been in the past.

'ARTHUR W. RÜCKER,
'*President.*

'March 1902.'

Invitations for future meetings will be presented from Cambridge and Cape Town.

The Report of the Corresponding Societies Committee for the past year, together with the list of the Corresponding Societies and the titles of the more important papers, especially those referring to Local Scientific Investigations, published by those Societies during the year ending May 31, 1902, has been received.

The Corresponding Societies Committee, consisting of Mr. W. Whitaker (*Chairman*), Dr. Francis Galton, Professor Meldola, Mr. T. V. Holmes, Sir J. Evans, Mr. J. Hopkinson, Dr. H. R. Mill, Mr. Horace T. Brown, Rev. J. O. Bevan, Professor W. W. Watts, Rev. T. R. R. Stebbing, Mr. C. H. Read, Mr. F. W. Rudler, and Dr. Vaughan Cornish, is hereby nominated for reappointment by the General Committee.

The Council nominate Professor W. W. Watts, Chairman; Mr. J. H. Merivale, Vice-Chairman; and Mr. Edward J. Bles, Secretary, to the Conference of Delegates of Corresponding Societies to be held during the Meeting at Belfast.

In accordance with the regulations the retiring Members of the Council will be:—

Sir Norman Lockyer.
Sir W. H. Preece.
Professor E. B. Tylor.
Dr. E. Ray Lankester.
Mr. J. E. Marr.

The nomination of Major MacMahon as General Secretary creates another vacancy.

The Council recommend the re-election of the other ordinary Members of the Council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list :—

*Abney, Sir W., K.C.B., F.R.S.
Armstrong, Professor H. E., F.R.S.
Bonar, J., Esq., LL.D.
Bower, Professor F. O., F.R.S.
Callendar, Professor H. L., F.R.S.
Creak, Captain E. W., C.B., R.N., F.R.S.
*Cunningham, Professor D. J., F.R.S.
Darwin, Major L., Sec. R.G.S.
Fremantle, The Hon. Sir C. W., K.C.B.
Gotch, Professor F., F.R.S.
*Haddon, Professor A. C., F.R.S.
Halliburton, Professor W. D., F.R.S.
*Hawksley, C., Esq., M.Inst.C.E.
*Howes, Professor G. B., F.R.S.
Keltie, J. Scott, Esq., LL.D.
Lodge, Sir Oliver, F.R.S.
Macalister, Professor A., F.R.S.
Perkin, Professor W. H., F.R.S.
Perry, Professor John, F.R.S.
Price, L. L., Esq., M.A.
Seward, A. C., Esq., F.R.S.
Sollas, Professor W. J., F.R.S.
Tilden, Professor W. A., F.R.S.
*Watts, Professor W. W., F.G.S.
Wolfe-Barry, Sir John, K.C.B., F.R.S.

COMMITTEES APPOINTED BY THE GENERAL COMMITTEE AT THE BELFAST MEETING IN SEPTEMBER 1902.

1. *Receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee	Grants
	SECTION A.—MATHEMATICS AND PHYSICS.	
		£ s. d.
Making Experiments for improving the Construction of Practical Standards for use in Electrical Measurements. [And balance in hand.]	*Chairman.*—Lord Rayleigh. *Secretary.*—Dr. R. T. Glazebrook. Lord Kelvin, Professors W. E. Ayrton, J. Perry, W. G. Adams, and G. Carey Foster, Sir Oliver Lodge, Dr. A. Muirhead, Sir W. H. Preece, Professors J. D. Everett and A. Schuster, Dr. J. A. Fleming, Professor J. J. Thomson, Mr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Dr. G. Johnstone Stoney, Professor S. P. Thompson, Mr. J. Rennie, Mr. E. H. Griffiths, Sir A. W. Rücker, Professors H. L. Callendar and Sir W. C. Roberts-Austen, and Mr. G. Matthey.	35 0 0
Seismological Observations.	*Chairman.*—Prof. J. W. Judd. *Secretary.*—Professor J. Milne. Lord Kelvin, Professor T. G. Bonney, Mr. C. V. Boys, Professor G. H. Darwin, Mr. Horace Darwin, Major L. Darwin, Professor J. A. Ewing, Dr. R. T. Glazebrook, Professor C. G. Knott, Professor R. Meldola, Mr. R. D. Oldham, Professor J. Perry, Mr. W. E. Plummer, Professor J. H. Poynting, Mr. Clement Reid, Mr. Nelson Richardson, and Professor H. H. Turner.	40 0 0
To co-operate with the Royal Meteorological Society in initiating an Investigation of the Upper Atmosphere by means of Kites.	*Chairman.*—Dr. W. N. Shaw. *Secretary.*—Mr. W. H. Dines. Mr. D. Archibald, Mr. C. Vernon Boys, Dr. A. Buchan, Dr. H. R. Mill, Dr. R. T. Glazebrook, and Dr. A. Schuster.	75 0 0
To co-operate with the Committee of the Falmouth Observatory in their Magnetic Observations.	*Chairman.*—Sir W. H. Preece. *Secretary.*—Dr. R. T. Glazebrook. Professor W. G. Adams, Captain Creak, Mr. W. F. Fox, Professor A. Schuster, and Sir A. W. Rücker	40 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
	SECTION B.—CHEMISTRY.	
		£ s. d.
Preparing a new Series of Wave-length Tables of the Spectra of the Elements.	*Chairman.*—Sir H. E. Roscoe. *Secretary.*—Dr. Marshall Watts. Sir J. N. Lockyer, Professors J. Dewar, G. D. Liveing, A. Schuster, W. N. Hartley, and Wolcott Gibbs, and Sir W. de W. Abney.	5 0 0
The Study of Hydro-aromatic Substances.	*Chairman.*—Professor E. Divers. *Secretary.*—Dr. A. W. Crossley. Professor W. H. Perkin, jun., Dr. M. O. Forster, and Dr. Le Sueur.	20 0 0
	SECTION C.—GEOLOGY.	
To investigate the Erratic Blocks of the British Isles, and to take measures for their preservation.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Mr. P. F. Kendall. Professor T. G. Bonney, Mr. C. E. De Rance, Professor W. J. Sollas, Mr. R. H. Tiddeman, Rev. S. N. Harrison, Mr. J. Horne, Mr. F. M. Burton, Mr. J. Lomas, Mr. A. R. Dwerryhouse, Mr. J. W. Stather, Mr. W. T. Tucker, and Mr. F. W. Harmer.	10 0 0
To explore Irish Caves. [Collections to be placed in the Science and Art Museum, Dublin.]	*Chairman.*—Dr. R. F. Scharff. *Secretary.*—Mr. R. Lloyd Praeger. Mr. G. Coffey, Professor Grenville Cole, Dr. Cunningham, Mr. G. W. Lamplugh, Mr. A. McHenry, and Mr. R. J. Ussher.	40 0 0
The movements of Underground Waters of North-west Yorkshire.	*Chairman.*—Professor W. W. Watts. *Secretary.*—Mr. A. R. Dwerryhouse. Professor A. Smithells, Rev. E. Jones, Mr. Walter Morrison, Mr. G. Bray, Rev. W. Lower Carter, Mr. T. Fairley, Mr. P. F. Kendall, and Mr. J. E. Marr.	40 0 0
To study Life-zones in the British Carboniferous Rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Dr. Wheelton Hind. Mr. F. A. Bather, Mr. G. C. Crick, Mr. A. H. Foord, Mr. H. Fox, Professor E. J. Garwood, Dr. G. J. Hinde, Mr. P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. B. N. Peach, Mr. A. Strahan, and Dr. H. Woodward.	5 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants		
		£	s.	d.
The Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.	*Chairman.*—Professor J. Geikie. *Secretary.*—Professor W. W. Watts. Professor T. G. Bonney, Dr. T. Anderson, Professors E. J. Garwood and S. H. Reynolds, and Messrs. A. S. Reid, W. Gray, H. B. Woodward, R. Kidston, J. J. H. Teall, J. G. Goodchild, H. Coates, C. V. Crook, G. Bingley, R. Welch, and A. K. Coomáraswámy.	10	0	0
To report upon the Fauna and Flora of the Trias of the British Isles.	*Chairman.*—Professor W. A. Herdman. *Secretary.*—Mr. J. Lomas. Professor W. W. Watts and Messrs. P. F. Kendall, E. T. Newton, A. C. Seward, and W. A. E. Ussher.	5	0	0

SECTION D.—ZOOLOGY.

Subject for Investigation or Purpose	Members of the Committee	£	s.	d.
To enable Mr. W. Wallace to investigate Viviparous Fishes and Dr. F. W. Gamble to study the Physiology of the Pigments of the Higher Crustacea, and to aid other competent investigators to carry on research at the Zoological Station at Naples.	*Chairman.*—Professor G. B. Howes. *Secretary.*—Mr. J. E. S. Moore. Professor E. Ray Lankester, Professor W. F. R. Weldon, Professor S. J. Hickson, Mr. A. Sedgwick, and Professor W. C. McIntosh.	100	0	0
Compilation of an Index Generum et Specierum Animalium.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. F. A. Bather. Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Mr. R. McLachlan, and Mr. W. E. Hoyle.	100	0	0

SECTION E.—GEOGRAPHY.

Subject for Investigation or Purpose	Members of the Committee	£	s.	d.
Tidal Bore, Sea Waves, and Beaches.	*Chairman.*—Dr. J. Scott Keltie. *Secretary.*—Dr. Vaughan Cornish. Lieut.-Col. F. Bailey, Mr. E. A. Floyer, Mr. John Milne, and Mr. W. H. Wheeler.	15	0	0
The Geography of the Antarctic Regions in the Area to be explored by the Scottish National Antarctic Expedition.	*Chairman.*—Sir T. H. Holdich. *Secretary.*—Lieut.-Col. F. Bailey. Mr. W. S. Bruce.	50	0	0

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

Subject for Investigation or Purpose	Members of the Committee	£	s.	d.
The Economic Effect of Legislation regulating Women's Labour. [And balance in hand.]	*Chairman.*—Mr. E. W. Brabrook. *Secretary.*—Mr. A. L. Bowley. Miss A. M Anderson, Miss Blackburn, Mr. C. Booth, Mr. S. J. Chapman, Miss C. E. Collet, Professor Edgeworth, Mrs. J. R. MacDonald, Mr. L. L. Price, Professor Smart, Dr. G. Adam Smith, and Mrs. H. J. Tennant.	25	0	0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
SECTION G.—ENGINEERING.		
		£ s. d.
To consider means by which better practical effect can be given to the Introduction of the Screw Gauge proposed by the Association in 1884.	*Chairman.*—Sir W. H. Preece. *Secretary.*—Mr. W. A. Price. Lord Kelvin, Sir F. J. Bramwell, Sir H. Trueman Wood, Maj.-Gen. Webber, Mr. R. E. Crompton, Mr. A. Stroh, Mr. A. Le Neve Foster, Mr. C. J. Hewitt, Mr. G. K. B. Elphinstone, Col. Watkin, Mr. E. Rigg, Mr. Vernon Boys, Mr. J. Marshall Gorham, Mr. O. P. Clements, Mr. W. Taylor, and Dr. R. T. Glazebrook.	5 0 0
To investigate the Resistance of Road Vehicles to Traction.	*Chairman.*—Sir Alexander Binnie. *Secretary.*—Professor H. S. Hele-Shaw. Mr. Aitken, Mr. Aveling, Professor T. Hudson Beare, Mr. W. W. Beaumont, Mr. J. Brown, Col. R. E. Crompton, Mr. A. Mallock, Sir D. Salomons, Mr. A. Sennett, Mr. E. Shrapnell Smith, and Sir J. I. Thornycroft.	90 0 0
SECTION H.—ANTHROPOLOGY.		
To conduct Archæological and Ethnological Researches in Crete.	*Chairman.*—Sir John Evans. *Secretary.*—Mr. J. L. Myres. Mr. A. J. Evans, Mr. D. G. Hogarth, Professor A. Macalister, and Professor W. Ridgeway.	100 0 0
To conduct Explorations with the object of ascertaining the Age of Stone Circles.	*Chairman.*—Mr. C. H. Read. *Secretary.*—Mr. H. Balfour. Sir John Evans, Dr. J. G. Garson, Professor Meldola, Mr. A. J. Evans, Dr. R. Munro, Professor Boyd Dawkins, and Mr. A. L. Lewis.	5 0 0
The Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest. [Balance in hand.]	*Chairman.*—Mr. C. H. Read. *Secretary.*—Mr. J. L. Myres. Dr. J. G. Garson, Mr. H. Ling Roth, Mr. H. Balfour, Dr. A. C. Haddon, Mr. E. S. Hartland, and Professor Flinders Petrie.	—
To organise Anthropometric Investigation in Great Britain and Ireland.	*Chairman.*—Professor J. Cleland. *Secretary.*—Mr. J. Gray. Professor D. J. Cunningham, Dr. T. H. Bryce, Dr. A. C. Haddon, Mr. J. L. Myres, Professor A. F. Dixon, Mr. E. N. Fallaize, and Dr. D. Hepburn.	5 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants £	s.	d.
To investigate the Psychology and Sociology of the Todas and other Tribes of Southern India.	*Chairman.*—Professor Ridgeway. *Secretary.*—Dr. W. H. R. Rivers. Dr. A. C. Haddon and Mr. W. Crooke.	50	0	0
SECTION I.—PHYSIOLOGY.				
The State of Solution of Proteids.	*Chairman.*—Professor W. D. Halliburton. *Secretary.*—Professor E. Waymouth Reid. Professor E. A. Schäfer.	20	0	0
SECTION K.—BOTANY.				
To consider and report upon a scheme for the Registration of Negatives of Botanical Photographs.	*Chairman.*—Professor L. C. Miall. *Secretary.*—Professor F. E. Weiss. Mr. Francis Darwin, Professor G. F. Scott-Elliot, and Mr. A. K. Coomáraswámy.	3	0	0
Investigation of the Cyanophyceæ.	*Chairman.* — Professor J. B. Farmer. *Secretary.*—Dr. F. F. Blackman. Professor Marshall Ward, Mr. W. Gardiner, and Dr. D. H. Scott.	25	0	0
Investigation on the Respiration of Plants.	*Chairman.* — Professor Marshall Ward. *Secretary.*—Mr. H. Wager. Mr. Francis Darwin and Professor J. B. Farmer.	12	0	0
SECTION L.—EDUCATIONAL SCIENCE.				
The conditions of Health essential to the carrying on of the work of instruction in schools.	*Chairman.*—Professor Sherrington. *Secretary.*—Mr. E. White Wallis. Dr. C. W. Kimmins, Professor L. C. Miall, Professor H. L. Withers, Miss Findlay, Miss Alice Ravenhill, Miss Maitland, Dr. Clement Dukes, Dr. Rivers, Mr. J. Russell, Dr. Sydney Stephenson, Dr. C. Childs, Dr. C. Shelley, and Mr. E. W. Brabrook.	10	0	0
CORRESPONDING SOCIETIES.				
Corresponding Societies Committee for the preparation of their Report.	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. F. W. Rudler. Dr. Francis Galton, Professor R. Meldola, Mr. T. V. Holmes, Sir John Evans, Mr. J. Hopkinson, Dr. H. R. Mill, Mr. Horace T. Brown, Rev. J. O. Bevan, Professor W. W. Watts, Rev. T. R. R. Stebbing, Mr. C. H. Read, and Dr. Vaughan Cornish.	20	0	0

2. *Not receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee
SECTION A.—MATHEMATICS AND PHYSICS.	
Radiation from a Source of Light in a Magnetic Field.	*Chairman.*—Professor A. Schuster. *Secretary.*—Mr. W. E. Thrift. Sir Oliver Lodge, Professor S. P. Thompson, Dr. Gerald Molloy, Dr. W. E. Adeney, and Mr. E. P. Culverwell.
To establish a Meteorological Observatory on Mount Royal, Montreal.	*Chairman.*— Professor H. L. Callendar. *Secretary.*—Professor C. H. McLeod. Professor F. Adams and Mr. R. F. Stupart.
Co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis.	*Chairman.*—Lord McLaren. *Secretary.*—Professor Crum Brown. Sir John Murray, Dr. A. Buchan, and Professor R. Copeland.
The Rate of Increase of Underground Temperature downwards in various Localities of Dry Land and under Water.	*Chairman* and *Secretary.*—Professor J. D. Everett. Lord Kelvin, Sir Archibald Geikie, Mr. James Glaisher, Professor Edward Hull, Dr. C. Le Neve Foster, Professor A. S. Herschel, Professor G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. E. Wethered, Mr. A. Strahan, Professor Michie Smith, Professor H. L. Callendar, and Mr. B. H. Brough.
Considering the best Methods of Recording the Direct Intensity of Solar Radiation.	*Chairman.*— Dr. G. Johnstone Stoney. *Secretary.*—Professor H. McLeod. Sir G. G. Stokes, Professor A. Schuster, Sir H. E. Roscoe, Captain Sir W. de W. Abney, Dr. C. Chree, Professor H. L. Callendar, Mr. W. E. Wilson, and Professor A. A. Rambaut.
That Miss Hardcastle be requested to draw up a Report on the present state of the Theory of Point-groups.	
SECTION B.—CHEMISTRY.	
The Nature of Alloys.	*Chairman* and *Secretary.*— Mr. F. H. Neville Mr. C. T. Heycock and Mr. E. H. Griffiths.
Isomeric Naphthalene Derivatives.	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Professor H. E. Armstrong.
The Study of Isomorphous Sulphonic Derivatives of Benzene.	*Chairman.*—Professor H. A. Miers. *Secretary.*—Professor H. E. Armstrong. Dr. W. P. Wynne and Mr. W. J. Pope.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To approach the Inland Revenue Commissioners to urge the desirability of securing the use of pure alcohol duty free for the purposes of scientific research.	*Chairman.*—Sir H. E. Roscoe. *Secretary.*—Professor H. B. Dixon. Sir Michael Foster, Sir A. W. Rücker, Dr. T. E. Thorpe, Professor W. H. Perkin, and Professor W. D. Halliburton.
The Relation between the Absorption Spectra and Chemical Constitution of Organic Substances.	*Chairman* and *Secretary.*—Professor W. Noel Hartley. Professor F. R. Japp, Professor J. J. Dobbie, and Mr. Alexander Lauder.
The action of Gases dissolved in Metals and Alloys on their Properties.	*Chairman.*—Sir Wm. C. Roberts-Austen. *Secretary.*—Dr. T. K. Rose. Mr. W. Carrick Anderson, Professor H. B. Dixon, Mr. C. T. Heycock, Mr. F. H. Neville, and Sir W. Ramsay.
To consider and report on the possibility of making special Reports more available than at present by indexing and by the wider distribution of them.	*Chairman.*—Professor W. A. Shenstone. *Secretary.*—Dr. M. O. Forster. Professor E. Divers, Professor W. J. Pope, and Dr. A. W. Crossley.

SECTION C.—GEOLOGY.

To report upon the present state of our Knowledge of the Structure of Crystals.	*Chairman.*—Professor N. Story Maskelyne. *Secretary.*—Professor H. A. Miers. Mr. L. Fletcher, Professor W. J. Sollas, Mr. W. Barlow, Mr. G. F. H. Smith, and the Earl of Berkeley.
To consider the best Methods for the Registration of all Type Specimens of Fossils in the British Isles, and to report on the same.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. A. Smith Woodward. Rev. G. F. Whidborne, Mr. R. Kidston, Professor H. G. Seeley, Mr. H. Woods, and Rev. J. F. Blake.
To investigate the Estuarine Deposit at Kirmington, Lincolnshire, and to consider its position with regard to the Glacial Deposits.	*Chairman.*—Mr. G. W. Lamplugh. *Secretary.*—Mr. J. W. Stather. Professor P. F. Kendall, Mr. Clement Reid, Mr. F. W. Harmer, and Mr. T. Sheppard.

SECTION D.—ZOOLOGY.

To investigate the structure, formation, and growth of the Coral Reefs of the Indian Region, with special observations on the inter-relationship of the reef organisms, the depths at which they grow, the food of corals, effects of currents and character of the ocean bottom, &c. The land flora and fauna will be collected, and it is intended that observations shall be made on the manners, &c., of the natives in the different parts of the Maldive group.	*Chairman.*—Mr. A. Sedgwick. *Secretary.*—Mr. J. Stanley Gardiner. Professor J. W. Judd, Mr. J. J. Lister, Mr. Francis Darwin, Dr. S. F. Harmer, and Professors A. Macalister, W. A. Herdman, and S. J. Hickson.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To continue the investigation of the Zoology of the Sandwich Islands, with power to co-operate with the Committee appointed for the purpose by the Royal Society, and to avail themselves of such assistance in their investigations as may be offered by the Hawaiian Government or the Trustees of the Museum at Honolulu. The Committee to have power to dispose of specimens where advisable.	*Chairman.*—Professor A. Newton. *Secretary.*—Dr. David Sharp. Dr. W. T. Blanford, Professor S. J. Hickson, Dr. P. L. Sclater, Mr. F. Du Cane Godman, and Mr. Edgar A. Smith.
To enable Mr. James Rankin to investigate Compound Ascidians of the Clyde area, and to enable other competent naturalists to perform definite researches in the Laboratory of the Marine Biological Association of the West of Scotland at Millport.	*Chairman.*—Sir John Murray. *Secretary.*—Dr. J. F. Gemmill. Professor F. O. Bower, Professor Cossar Ewart, Professor W. A. Herdman, Professor M. Laurie, Mr. Alex. Somerville, and Mr. J. A. Todd.
To enable Mr. R. C. Punnett to continue his investigations on the pelvic plexus of Elasmobranch fishes, and to enable other competent naturalists to perform definite pieces of work at the Marine Laboratory, Plymouth.	*Chairman* and *Secretary.*—Mr. W. Garstang. Professor E. Ray Lankester, Professor Sydney H. Vines, Mr. A. Sedgwick, and Professor W. F. R. Weldon.
To work out the details of the Observations on the Migration of Birds at Lighthouses and Lightships, 1880–87.	*Chairman.*—Professor A. Newton. *Secretary.*—Rev. E. P. Knubley. Mr. John A. Harvie-Brown, Mr. R. M. Barrington, Mr. A. H. Evans, and Dr. H. O. Forbes.
The Periodic Investigation of the Plankton and Physical Conditions of the English Channel.	*Chairman.*—Professor E. Ray Lankester. *Secretary.*—Mr. Walter Garstang. Professor W. A. Herdman and Mr. H. N. Dickson.

SECTION H.—ANTHROPOLOGY.

The present state of Anthropological Teaching in the United Kingdom and elsewhere.	*Chairman.*—Professor E. B. Tylor. *Secretary.*—Mr. J. L. Myres. Professor A. Macalister, Dr. A. C. Haddon, Mr. C. H. Read, Mr. H. Balfour, Mr. F. W. Rudler, Dr. R. Munro, Professor Flinders Petrie, Mr. H. Ling Roth, and Professor D. J. Cunningham.
To organise an Ethnological Survey of Canada.	*Chairman.*—Professor D. P. Penhallow. *Secretary.*—Mr. C. Hill-Tout. Mr. E. W. Brabrook, Dr. A. C. Haddon, Mr. E. S. Hartland, Sir J. G. Bourinot, Mr. B. Sulte, Mr. David Boyle, Mr. C. N. Bell, Professor E. B. Tylor, Professor J. Mavor, Mr. A. F. Hunter, and Dr. W. F Ganong.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To co-operate with the Cardiff Naturalists' Society in its Excavations on the Roman Site at Gelligaer.	*Chairman.*—Professor J. Rhys. *Secretary.*—Mr. J. L. Myres. Mr. A. J. Evans and Mr. E. W. Brabrook.
To organise a Pigmentation Survey of the school children of Scotland.	*Chairman.*—Mr. E. W. Brabrook. *Secretary.*—Mr. J. Gray. Dr. A. C. Haddon, Professor A. Macalister, Professor D. J. Cunningham, Mr. J. F. Tocher, and Dr. W. H. R. Rivers.
To conduct Anthropometric Investigations among the Native Troops of the Egyptian Army.	*Chairman.*—Professor A. Macalister. *Secretary.*—Mr. C. S. Myers. Sir John Evans and Professor D. J. Cunningham.
To investigate the Lake Village at Glastonbury, and to report on the best method of publication of the result.	*Chairman.*—Dr. R. Munro. *Secretary.*—Professor W. Boyd Dawkins. Sir John Evans, Mr. Arthur J. Evans, Mr. C. H. Read, and Mr. A. Bulleid.
To co-operate with the Silchester Excavation Fund Committee in their explorations.	*Chairman.*—Mr. A. J. Evans. *Secretary.*—Mr. John L. Myres. Mr. E. W. Brabrook.
To report on the present state of knowledge of the Ethnography, Folklore, and Languages of the Peoples of the Pacific.	*Chairman.*—Professor E. B. Tylor. *Secretary.*—Dr. A. C. Haddon. Mr. H. Balfour and Mr. J. Stanley Gardiner.

SECTION I.—PHYSIOLOGY.

The Physiological Effects of Peptone and its Precursors when introduced into the circulation.	*Chairman.*—Professor E. A. Schäfer. *Secretary.*—Professor W. H. Thompson. Professor R. Boyce and Professor C. S. Sherrington.
The Micro-chemistry of Cells.	*Chairman.*—Professor E. A. Schäfer. *Secretary.*—Professor A. B. Macallum. Professor E. Ray Lankester, Professor W. D. Halliburton, Mr. G. C. Bourne, and Professor J. J. Mackenzie.
To investigate the Functions of the Rods and Cones in the Mammalian Retina with reference to the Visual Purple.	*Chairman.*—Professor J. G. McKendrick. *Secretary.*—Dr. F. W. Edridge Green. Professors E. H. Starling and A. D. Waller.

SECTION L.—EDUCATIONAL SCIENCE.

The Teaching of Natural Science in Elementary Schools.	*Chairman.*—Dr. J. H. Gladstone. *Secretary.*—Professor H. E. Armstrong. Lord Avebury, Mr. George Gladstone, Professor W. R. Dunstan, Sir Philip Magnus, Sir H. E. Roscoe, Dr. Silvanus P. Thompson, and Professor A. Smithells.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To report upon improvements that might be effected in the teaching of Mathematics, in the first instance in the teaching of Elementary Mathematics, and upon such means as they think likely to effect such improvements.	*Chairman.*—Professor A. R. Forsyth. *Secretary.*—Professor J. Perry. Sir A. W. Rücker, Sir O. J. Lodge, Major P. A. MacMahon, Professor W. H. H. Hudson, Dr. J. Larmor, Professors S. P. Thompson, G. Chrystal, O. Henrici, A. Lodge, A. G. Greenhill, and G. M. Minchin, Mr. W. D. Eggar, Mr. H. W. Eve, Dr. Gladstone, Professor Gibson, Professor Robert Russell, Mr. R. A. Gregory, and Professor Love.
To consider and report upon the influence exercised by Universities and Examining Bodies on secondary school curricula, and also of the schools on university requirements.	*Chairman.*—Dr. H. E. Armstrong. *Secretary.*—Mr. R. A. Gregory. The Bishop of Hereford, Sir Michael Foster, Sir P. Magnus, Sir A. W. Rücker, Sir O. J. Lodge, Mr. H. W. Eve, Mr. W. A. Shenstone, Mr. Eggar, Professor Marshall Ward, Mr. F. H. Neville, Mrs. W. N. Shaw, Professor H. L. Withers, and Dr. C. W. Kimmins.
The Teaching of Botany in Schools.	*Chairman.*—Professor L. C. Miall. *Secretary.*—Mr. Harold Wager. Professor J. R. Green, Mr. A. C. Seward, Professors H. M. Ward, J. B. Farmer, and T. Johnson, Miss Lillian Clarke, and Dr. C. W. Kimmins.

Communications ordered to be printed in extenso.

Our Present Knowledge of Aromatic Diazo-compounds, by G. T. Morgan, D.Sc.

Hydro-aromatic Compounds with Single Nucleus, by A. W. Crossley, D.Sc., Ph.D.

Resolutions referred to the Council for consideration, and action if desirable.

That the Council be requested to impress upon His Majesty's Government the desirability of appointing an Inspector of Ancient Monuments under the Ancient Monuments Act in the place of the late Lieut.-General Pitt-Rivers.

That the Council be requested to call the attention of His Majesty's Government to the destruction of Ancient Monuments, especially on Dartmoor, which is authorised under the terms of the Highway Act, 5 & 6 Wm. IV., c 50, the provisions of which are unrepealed by later Acts; and to urge the repeal of this section of the Act.

That the attention of the Royal Irish Academy be drawn to the importance of organising and carrying out a Pigmentation Survey of School Children in Ireland.

Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Belfast Meeting, September 1902. *The Names of the Members entitled to call on the General Treasurer for the respective Grants are prefixed.*

	£	s.	d.
Mathematics and Physics.			
*Rayleigh, Lord—Electrical Standards	35	0	0
*Judd, Professor J. W.—Seismological Observations	40	0	0
*Shaw, Dr. W. N.—Investigation of the Upper Atmosphere by means of Kites	75	0	0
*Preece, Sir W. H.—Magnetic Observations at Falmouth	40	0	0
Chemistry.			
*Roscoe, Sir H. E.—Wave-length Tables	5	0	0
Divers, Dr. E.—Study of Hydro-aromatic Substances	20	0	0
Geology.			
*Marr, Mr. J. E.—Erratic Blocks	10	0	0
*Scharff, Dr.—Exploration of Irish Caves	40	0	0
*Watts, Professor W. W.—Underground Waters of North-west Yorkshire	40	0	0
*Marr, Mr. J. E.—Life-zones in British Carboniferous Rocks	5	0	0
*Geikie, Professor J.—Geological Photographs	10	0	0
Herdman, Professor W. A.—Fauna and Flora of British Trias	5	0	0
Zoology.			
*Howes, Professor G. B.—Table at the Zoological Station, Naples	100	0	0
*Woodward, Dr. H.—Index Generum et Specierum Animalium	100	0	0
Geography.			
Keltie, Dr. J. Scott—Tidal Bore, Sea Waves, and Beaches	15	0	0
Holdich, Sir T. H.—Scottish National Antarctic Expedition	50	0	0
Economic Science and Statistics.			
*Brabrook, E. W.—Legislation regulating Women's Labour	25	0	0
Engineering.			
*Preece, Sir W. H.—Small Screw Gauge	5	0	0
*Binnie, Sir A.—Resistance of Road Vehicles to Traction	90	0	0
Carried forward	£710	0	0

* Reappointed.

	£	s.	d.
Brought forward	710	0	0

Anthropology.

	£	s.	d.
*Evans, Sir John—Researches in Crete	100	0	0
*Read, Mr. C. H.—Age of Stone Circles	5	0	0
*Read, Mr. C. H.—Anthropological Photographs (Balance in hand)	—		
Cleland, Professor J.—Anthropometric Investigation	5	0	0
Ridgeway, Professor—Anthropology of the Todas and other Tribes of Southern India	50	0	0

Physiology.

	£	s.	d.
Halliburton, Professor W. D.—The State of Solution of Proteids	20	0	0

Botany.

	£	s.	d.
*Miall, Professor L. C.—Registration of Botanical Photographs	3	0	0
*Farmer, Professor J. B.—Investigations of the Cyanophyceæ	25	0	0
*Ward, Professor Marshall—The Respiration of Plants	12	0	0

Educational Science.

	£	s.	d.
*Sherrington, Professor—Conditions of Health essential for School Instruction	10	0	0

Corresponding Societies.

	£	s.	d.
*Whitaker, Mr. W.—Preparing Report, &c.	20	0	0
	£960	0	0

* Reappointed.

The Annual Meeting in 1903.

The Annual Meeting of the Association in 1903 will be held at Southport, commencing on September 9.

The Annual Meeting in 1904.

The Annual Meeting of the Association in 1904 will be held at Cambridge.

General Statement of Sums which have been paid on account of Grants for Scientific Purposes

1834.

	£	s.	d.
Tide Discussions	20	0	0

1835.

Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0

1836.

Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on Long-continued Heat	17	1	0
Rain-gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£435	0	0

1837.

Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	93	3	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£922	12	6

1838.

Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
	£932	2	2

1839.

	£	s.	d.
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth, &c.	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	0
Cast-iron Experiments	103	0	7
Railway Constants	28	7	0
Land and Sea Level	274	1	2
Steam-vessels' Engines	100	0	4
Stars in Histoire Céleste	171	18	0
Stars in Lacaille	11	0	6
Stars in R.A.S. Catalogue	166	16	0
Animal Secretions	10	10	6
Steam Engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0

1840.

Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4

1841.

	£	s.	d.
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	6
Railway Sections	38	1	0
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Firth of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture, and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8

	£	s.	d.
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East Coast of Scotland ...	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment at Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells ...	20	0	0
Radiata and Mollusca of the Ægean and Red Seas 1842	100	0	0
Geographical Distributions of Marine Zoology.........1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu......	10	0	0
Experiments on the Vitality of Seeds	9	0	0
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals......	50	0	0
Constant Indicator and Morin's Instrument 1842	10	0	0
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh..................	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment at Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces...	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall .	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York..	20	0	0
Earthquake Shocks 1843	15	14	8
	£831	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay..............................	100	0	0
Computation of the Gaussian Constants for 1829	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain ...	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers.................	11	7	6
Anemometers' Repairs...	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1829	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogue of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8

1849.

	£	s.	d.
Electrical Observations at Kew Observatory	50	0	0
Maintaining the Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on Account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phenomena	15	0	0
Meteorological Instruments, Azores	25	0	0
	£345	18	0

1851.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

1853.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0

1854.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7

1855.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4

1856.

	£	s.	d.
Maintaining the Establishment at Kew Observatory:— 1854......... £75 0 0 1855........ £500 0 0	575	0	0

	£	s.	d.
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	0
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9

1857.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-boats	5	0	0
	£507	15	4

1858.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seed	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£766	19	6

1861.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860......£50 0 0 1861......£22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahagow	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	10
Constituents of Manures	25	0	0
	£1111	5	10

1862.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. of America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland Coasts	25	0	0
Connection of Storms	20	0	0
Dredging North-east Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-electric Currents	5	0	0
	£1293	16	6

1863.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east Coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
Electrical Construction and Distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroida	10	0	0
	£1608	3	10

1864.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging, Shetland	75	0	0
Dredging, Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	9
Rain-gauges	19	15	8
Cast-iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	10
Luminous Meteors	40	0	0
	£1591	7	10

1866.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-bed	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	20	0	0
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches	30	0	0
Palestine Exploration Fund	100	0	0
	£1750	13	4

1867.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Meteorological Instruments, Palestine	50	0	0
Lunar Committee	120	0	0
Metrical Committee	30	0	0
Kent's Hole Explorations	100	0	0
Palestine Explorations	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-bed	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c., Leaf-beds	30	0	0
Dredging Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards	100	0	0
Ethyl and Methyl Series	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds	100	0	0
Iron and Steel Manufacture	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Lunar Committee	120	0	0
Metrical Committee	50	0	0
Zoological Record	100	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	100	0	0
British Rainfall	50	0	0
Luminous Meteors	50	0	0
Organic Acids	60	0	0
Fossil Crustacea	25	0	0
Methyl Series	25	0	0
Mercury and Bile	25	0	0
Organic Remains in Limestone Rocks	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall	30	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

1869.

Maintaining the Establishment at Kew Observatory	600	0	0
Lunar Committee	50	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Gases in Deep-well Water	25	0	0
British Rainfall	50	0	0
Thermal Conductivity of Iron, &c.	30	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	30	0	0
Chemical Constitution of Cast Iron	80	0	0
Iron and Steel Manufacture	100	0	0
Methyl Series	30	0	0
Organic Remains in Limestone Rocks	10	0	0
Earthquakes in Scotland	10	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	30	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	30	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Organic Acids	12	0	0
Kiltorcan Fossils	20	0	0

	£	s.	d.
Chemical Constitution and Physiological Action Relations	15	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	10	0	0
Products of Digestion	10	0	0
	£1622	0	0

1870.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Marine Fauna	20	0	0
Ears in Fishes	10	0	0
Chemical Nature of Cast Iron	80	0	0
Luminous Meteors	30	0	0
Heat in the Blood	15	0	0
British Rainfall	100	0	0
Thermal Conductivity of Iron, &c.	20	0	0
British Fossil Corals	50	0	0
Kent's Hole Explorations	150	0	0
Scottish Earthquakes	4	0	0
Bagshot Leaf-beds	15	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Kiltorcan Quarries Fossils	20	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	50	0	0
Organic Chemical Compounds	30	0	0
Onny River Sediment	3	0	0
Mechanical Equivalent of Heat	50	0	0
	£1572	0	0

1871.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Monthly Reports of Progress in Chemistry	100	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Thermal Equivalents of the Oxides of Chlorine	10	0	0
Tidal Observations	100	0	0
Fossil Flora	25	0	0
Luminous Meteors	30	0	0
British Fossil Corals	25	0	0
Heat in the Blood	7	2	6
British Rainfall	50	0	0
Kent's Hole Explorations	150	0	0
Fossil Crustacea	25	0	0
Methyl Compounds	25	0	0
Lunar Objects	20	0	0
Fossil Coral Sections, for Photographing	20	0	0
Bagshot Leaf-beds	20	0	0
Moab Explorations	100	0	0
Gaussian Constants	40	0	0
	£1472	2	6

1872.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	300	0	0
Metrical Committee	75	0	0
Zoological Record	100	0	0
Tidal Committee	200	0	0
Carboniferous Corals	25	0	0
Organic Chemical Compounds	25	0	0
Exploration of Moab	100	0	0
Terato-embryological Inquiries	10	0	0
Kent's Cavern Exploration	100	0	0
Luminous Meteors	20	0	0
Heat in the Blood	15	0	0
Fossil Crustacea	25	0	0
Fossil Elephants of Malta	25	0	0
Lunar Objects	20	0	0
Inverse Wave-lengths	20	0	0
British Rainfall	100	0	0
Poisonous Substances Antagonism	10	0	0
Essential Oils, Chemical Constitution, &c.	40	0	0
Mathematical Tables	50	0	0
Thermal Conductivity of Metals	25	0	0
	£1285	0	0

1873.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	200	0	0
Tidal Committee	400	0	0
Sewage Committee	100	0	0
Kent's Cavern Exploration	150	0	0
Carboniferous Corals	25	0	0
Fossil Elephants	25	0	0
Wave-lengths	150	0	0
British Rainfall	100	0	0
Essential Oils	30	0	0
Mathematical Tables	100	0	0
Gaussian Constants	10	0	0
Sub-Wealden Explorations	25	0	0
Underground Temperature	150	0	0
Settle Cave Exploration	50	0	0
Fossil Flora, Ireland	20	0	0
Timber Denudation and Rainfall	20	0	0
Luminous Meteors	30	0	0
	£1685	0	0

1874.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	100	0	0
Mathematical Tables	100	0	0
Elliptic Functions	100	0	0
Lightning Conductors	10	0	0
Thermal Conductivity of Rocks	10	0	0
Anthropological Instructions	50	0	0
Kent's Cavern Exploration	150	0	0
Luminous Meteors	30	0	0
Intestinal Secretions	15	0	0
British Rainfall	100	0	0
Essential Oils	10	0	0
Sub-Wealden Explorations	25	0	0
Settle Cave Exploration	50	0	0
Mauritius Meteorology	100	0	0
Magnetisation of Iron	20	0	0
Marine Organisms	30	0	0
Fossils, North-West of Scotland	2	10	0
Physiological Action of Light	20	0	0
Trades Unions	25	0	0
Mountain Limestone-corals	25	0	0
Erratic Blocks	10	0	0
Dredging, Durham and Yorkshire Coasts	28	5	0
High Temperature of Bodies	30	0	0
Siemens's Pyrometer	3	6	0
Labyrinthodonts of Coal-measures	7	15	0
	£1151	16	0

1875.

	£	s.	d.
Elliptic Functions	100	0	0
Magnetisation of Iron	20	0	0
British Rainfall	120	0	0
Luminous Meteors	30	0	0
Chemistry Record	100	0	0
Specific Volume of Liquids	25	0	0
Estimation of Potash and Phosphoric Acid	10	0	0
Isometric Cresols	20	0	0
Sub-Wealden Explorations	100	0	0
Kent's Cavern Exploration	100	0	0
Settle Cave Exploration	50	0	0
Earthquakes in Scotland	15	0	0
Underground Waters	10	0	0
Development of Myxinoid Fishes	20	0	0
Zoological Record	100	0	0
Instructions for Travellers	20	0	0
Intestinal Secretions	20	0	0
Palestine Exploration	100	0	0
	£960	0	0

1876.

	£	s.	d.
Printing Mathematical Tables	159	4	2
British Rainfall	100	0	0
Ohm's Law	9	15	0
Tide Calculating Machine	200	0	0
Specific Volume of Liquids	25	0	0
Isomeric Cresols	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	5	0	0
Estimation of Potash and Phosphoric Acid	13	0	0
Exploration of Victoria Cave	100	0	0
Geological Record	100	0	0
Kent's Cavern Exploration	100	0	0
Thermal Conductivities of Rocks	10	0	0
Underground Waters	10	0	0
Earthquakes in Scotland	1	10	0
Zoological Record	100	0	0
Close Time	5	0	0
Physiological Action of Sound	25	0	0
Naples Zoological Station	75	0	0
Intestinal Secretions	15	0	0
Physical Characters of Inhabitants of British Isles	13	15	0
Measuring Speed of Ships	10	0	0
Effect of Propeller on turning of Steam-vessels	5	0	0
	£1092	4	2

1877.

	£	s.	d.
Liquid Carbonic Acid in Minerals	20	0	0
Elliptic Functions	250	0	0
Thermal Conductivity of Rocks	9	11	7
Zoological Record	100	0	0
Kent's Cavern	100	0	0
Zoological Station at Naples	75	0	0
Luminous Meteors	30	0	0
Elasticity of Wires	100	0	0
Dipterocarpeæ, Report on	20	0	0
Mechanical Equivalent of Heat	35	0	0
Double Compounds of Cobalt and Nickel	8	0	0
Underground Temperature	50	0	0
Settle Cave Exploration	100	0	0
Underground Waters in New Red Sandstone	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	10	0	0
British Earthworks	25	0	0
Atmospheric Electricity in India	15	0	0
Development of Light from Coal-gas	20	0	0
Estimation of Potash and Phosphoric Acid	1	18	0
Geological Record	100	0	0
Anthropometric Committee	34	0	0
Physiological Action of Phosphoric Acid, &c.	15	0	0
	£1128	9	7

1878.

	£	s.	d.
Exploration of Settle Caves	100	0	0
Geological Record	100	0	0
Investigation of Pulse Phenomena by means of Siphon Recorder	10	0	0
Zoological Station at Naples	75	0	0
Investigation of Underground Waters	15	0	0
Transmission of Electrical Impulses through Nerve Structure	30	0	0
Calculation of Factor Table for 4th Million	100	0	0
Anthropometric Committee	66	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Kent's Cavern	50	0	0
Zoological Record	100	0	0
Fermanagh Caves Exploration	15	0	0
Thermal Conductivity of Rocks	4	16	6
Luminous Meteors	10	0	0
Ancient Earthworks	25	0	0
	£725	16	6

1879.

	£	s.	d.
Table at the Zoological Station, Naples	75	0	0
Miocene Flora of the Basalt of the North of Ireland	20	0	0
Illustrations for a Monograph on the Mammoth	17	0	0
Record of Zoological Literature	100	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Caves in Borneo	50	0	0
Kent's Cavern Exploration	100	0	0
Record of the Progress of Geology	100	0	0
Fermanagh Caves Exploration	5	0	0
Electrolysis of Metallic Solutions and Solutions of Compound Salts	25	0	0
Anthropometric Committee	50	0	0
Natural History of Socotra	100	0	0
Calculation of Factor Tables for 5th and 6th Millions	150	0	0
Underground Waters	10	0	0
Steering of Screw Steamers	10	0	0
Improvements in Astronomical Clocks	30	0	0
Marine Zoology of South Devon	20	0	0
Determination of Mechanical Equivalent of Heat	12	15	6
Specific Inductive Capacity of Sprengel Vacuum	40	0	0
Tables of Sun-heat Coefficients	30	0	0
Datum Level of the Ordnance Survey	10	0	0
Tables of Fundamental Invariants of Algebraic Forms	36	14	9
Atmospheric Electricity Observations in Madeira	15	0	0
Instrument for Detecting Fire-damp in Mines	22	0	0
Instruments for Measuring the Speed of Ships	17	1	8
Tidal Observations in the English Channel	10	0	0
	£1080	11	11

1880.

	£	s.	d.
New Form of High Insulation Key	10	0	0
Underground Temperature	10	0	0
Determination of the Mechanical Equivalent of Heat	8	5	0
Elasticity of Wires	50	0	0
Luminous Meteors	30	0	0
Lunar Disturbance of Gravity	30	0	0
Fundamental Invariants	8	5	0
Laws of Water Friction	20	0	0
Specific Inductive Capacity of Sprengel Vacuum	20	0	0
Completion of Tables of Sun-heat Coefficients	50	0	0
Instrument for Detection of Fire-damp in Mines	10	0	0
Inductive Capacity of Crystals and Paraffines	4	17	7
Report on Carboniferous Polyzoa	10	0	0
Caves of South Ireland	10	0	0
Viviparous Nature of Ichthyosaurus	10	0	0
Kent's Cavern Exploration	50	0	0
Geological Record	100	0	0
Miocene Flora of the Basalt of North Ireland	15	0	0
Underground Waters of Permian Formations	5	0	0
Record of Zoological Literature	100	0	0
Table at Zoological Station at Naples	75	0	0
Investigation of the Geology and Zoology of Mexico	50	0	0
Anthropometry	50	0	0
Patent Laws	5	0	0
	£731	7	7

1881

	£	s.	d.
Lunar Disturbance of Gravity	30	0	0
Underground Temperature ...	20	0	0
Electrical Standards	25	0	0
High Insulation Key	5	0	0
Tidal Observations	10	0	0
Specific Refractions	7	3	1
Fossil Polyzoa	10	0	0
Underground Waters	10	0	0
Earthquakes in Japan	25	0	0
Tertiary Flora	20	0	0
Scottish Zoological Station ...	50	0	0
Naples Zoological Station ...	75	0	0
Natural History of Socotra ...	50	0	0
Anthropological Notes and Queries	9	0	0
Zoological Record	100	0	0
Weights and Heights of Human Beings	30	0	0
	£476	3	1

1882.

	£	s.	d.
Exploration of Central Africa	100	0	0
Fundamental Invariants of Algebraical Forms	76	1	11
Standards for Electrical Measurements	100	0	0
Calibration of Mercurial Thermometers	20	0	0
Wave-length Tables of Spectra of Elements	50	0	0
Photographing Ultra-violet Spark Spectra	25	0	0
Geological Record	100	0	0
Earthquake Phenomena of Japan	25	0	0
Conversion of Sedimentary Materials into Metamorphic Rocks	10	0	0
Fossil Plants of Halifax	15	0	0
Geological Map of Europe ...	25	0	0
Circulation of Underground Waters	15	0	0
Tertiary Flora of North of Ireland	20	0	0
British Polyzoa	10	0	0
Exploration of Caves of South of Ireland	10	0	0
Exploration of Raygill Fissure	20	0	0
Naples Zoological Station ...	80	0	0
Albuminoid Substances of Serum	10	0	0
Elimination of Nitrogen by Bodily Exercise	50	0	0
Migration of Birds	15	0	0
Natural History of Socotra ...	100	0	0
Natural History of Timor-laut	100	0	0
Record of Zoological Literature	100	0	0
Anthropometric Committee ...	50	0	0
	£1126	1	11

1883.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Isomeric Naphthalene Derivatives	15	0	0
Earthquake Phenomena of Japan	50	0	0
Fossil Plants of Halifax	20	0	0
British Fossil Polyzoa	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Erosion of Sea-coast of England and Wales	10	0	0
Circulation of Underground Waters	15	0	0
Geological Record	50	0	0
Exploration of Caves in South of Ireland	10	0	0
Zoological Literature Record	100	0	0
Migration of Birds	20	0	0
Zoological Station at Naples	80	0	0
Scottish Zoological Station ...	25	0	0
Elimination of Nitrogen by Bodily Exercise	38	3	3
Exploration of Mount Kilima-njaro	500	0	0
Investigation of Loughton Camp	10	0	0
Natural History of Timor-laut	50	0	0
Screw Gauges	5	0	0
	£1083	3	3

1884.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Collecting and Investigating Meteoric Dust	20	0	0
Meteorological Observatory at Chepstow	25	0	0
Tidal Observations	10	0	0
Ultra Violet Spark Spectra ...	8	4	0
Earthquake Phenomena of Japan	75	0	0
Fossil Plants of Halifax	15	0	0
Fossil Polyzoa	10	0	0
Erratic Blocks of England ...	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	15	0	0
Circulation of Underground Waters	5	0	0
International Geological Map	20	0	0
Bibliography of Groups of Invertebrata	50	0	0
Natural History of Timor-laut	50	0	0
Naples Zoological Station ...	80	0	0
Exploration of Mount Kilima-njaro, East Africa	500	0	0
Migration of Birds	20	0	0
Coagulation of Blood	100	0	0
Zoological Literature Record	100	0	0
Anthropometric Committee ...	10	0	0
	£1173	4	0

1885.

	£	s.	d.
Synoptic Chart of Indian Ocean	50	0	0
Reduction of Tidal Observations	10	0	0
Calculating Tables in Theory of Numbers	100	0	0
Meteorological Observations on Ben Nevis	50	0	0
Meteoric Dust	70	0	0
Vapour Pressures, &c., of Salt Solutions	25	0	0
Physical Constants of Solutions	20	0	0
Volcanic Phenomena of Vesuvius	25	0	0
Raygill Fissure	15	0	0
Earthquake Phenomena of Japan	70	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Fossil Plants of British Tertiary and Secondary Beds	50	0	0
Geological Record	50	0	0
Circulation of Underground Waters	10	0	0
Naples Zoological Station	100	0	0
Zoological Literature Record	100	0	0
Migration of Birds	30	0	0
Exploration of Mount Kilimanjaro	25	0	0
Recent Polyzoa	10	0	0
Granton Biological Station	100	0	0
Biological Stations on Coasts of United Kingdom	150	0	0
Exploration of New Guinea	200	0	0
Exploration of Mount Roraima	100	0	0
	£1385	0	0

1886.

	£	s.	d.
Electrical Standards	40	0	0
Solar Radiation	9	10	6
Tidal Observations	50	0	0
Magnetic Observations	10	10	0
Observations on Ben Nevis	100	0	0
Physical and Chemical Bearings of Electrolysis	20	0	0
Chemical Nomenclature	5	0	0
Fossil Plants of British Tertiary and Secondary Beds	20	0	0
Caves in North Wales	25	0	0
Volcanic Phenomena of Vesuvius	30	0	0
Geological Record	100	0	0
Palæozoic Phyllopoda	15	0	0
Zoological Literature Record	100	0	0
Granton Biological Station	75	0	0
Naples Zoological Station	50	0	0
Researches in Food-Fishes and Invertebrata at St. Andrews	75	0	0
Migration of Birds	30	0	0
Secretion of Urine	10	0	0
Exploration of New Guinea	150	0	0
Regulation of Wages under Sliding Scales	10	0	0
Prehistoric Race in Greek Islands	20	0	0
North-Western Tribes of Canada	50	0	0
	£995	0	6

1887.

	£	s.	d.
Solar Radiation	18	10	0
Electrolysis	30	0	0
Ben Nevis Observatory	75	0	0
Standards of Light (1886 grant)	20	0	0
Standards of Light (1887 grant)	10	0	0
Harmonic Analysis of Tidal Observations	15	0	0
Magnetic Observations	26	2	0
Electrical Standards	50	0	0
Silent Discharge of Electricity	20	0	0
Absorption Spectra	40	0	0
Nature of Solution	20	0	0
Influence of Silicon on Steel	30	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Volcanic Phenomena of Japan (1886 grant)	50	0	0
Volcanic Phenomena of Japan (1887 grant)	50	0	0
Cae Gwyn Cave, N. Wales	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	20	0	0
Coal Plants of Halifax	25	0	0
Microscopic Structure of the Rocks of Anglesey	10	0	0
Exploration of the Eocene Beds of the Isle of Wight	20	0	0
Underground Waters	5	0	0
'Manure' Gravels of Wexford	10	0	0
Provincial Museums Reports	5	0	0
Lymphatic System	25	0	0
Naples Biological Station	100	0	0
Plymouth Biological Station	50	0	0
Granton Biological Station	75	0	0
Zoological Record	100	0	0
Flora of China	75	0	0
Flora and Fauna of the Cameroons	75	0	0
Migration of Birds	30	0	0
Bathy-hypsographical Map of British Isles	7	6	0
Regulation of Wages	10	0	0
Prehistoric Race of Greek Islands	20	0	0
Racial Photographs, Egyptian	20	0	0
	£1186	18	0

1888

	£	s.	d.
Ben Nevis Observatory	150	0	0
Electrical Standards	2	6	4
Magnetic Observations	15	0	0
Standards of Light	79	2	3
Electrolysis	30	0	0
Uniform Nomenclature in Mechanics	10	0	0
Silent Discharge of Electricity	9	11	10
Properties of Solutions	25	0	0
Influence of Silicon on Steel	20	0	0
Methods of Teaching Chemistry	10	0	0
Isomeric Naphthalene Derivatives	25	0	0
Action of Light on Hydracids	20	0	0
Sea Beach near Bridlington	20	0	0
Geological Record	50	0	0
Manure Gravels of Wexford	10	0	0
Erosion of Sea Coasts	10	0	0
Underground Waters	5	0	0
Palæontographical Society	50	0	0
Pliocene Fauna of St. Erth	50	0	0
Carboniferous Flora of Lancashire and West Yorkshire	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Zoology and Botany of West Indies	100	0	0
Flora of Bahamas	100	0	0
Development of Fishes—St. Andrews	50	0	0
Marine Laboratory, Plymouth	100	0	0
Migration of Birds	30	0	0
Flora of China	75	0	0
Naples Zoological Station	100	0	0
Lymphatic System	25	0	0
Biological Station at Granton	50	0	0
Peradeniya Botanical Station	50	0	0
Development of Teleostei	15	0	0
Depth of Frozen Soil in Polar Regions	5	0	0
Precious Metals in Circulation	20	0	0
Value of Monetary Standard	10	0	0
Effect of Occupations on Physical Development	25	0	0
North-Western Tribes of Canada	100	0	0
Prehistoric Race in Greek Islands	20	0	0
	£1511	0	5

1889.

	£	s.	d.
Ben Nevis Observatory	50	0	0
Electrical Standards	75	0	0
Electrolysis	20	0	0
Surface Water Temperature	30	0	0
Silent Discharge of Electricity on Oxygen	6	4	8
Methods of teaching Chemistry	10	0	0
Action of Light on Hydracids	10	0	0
Geological Record	80	0	0
Volcanic Phenomena of Japan	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	20	0	0
Higher Eocene Beds of Isle of Wight	15	0	0
West Indian Explorations	100	0	0
Flora of China	25	0	0
Naples Zoological Station	100	0	0
Physiology of Lymphatic System	25	0	0
Experiments with a Tow-net	5	16	3
Natural History of Friendly Islands	100	0	0
Geology and Geography of Atlas Range	100	0	0
Action of Waves and Currents in Estuaries	100	0	0
North-Western Tribes of Canada	150	0	0
Nomad Tribes of Asia Minor	30	0	0
Corresponding Societies	20	0	0
Marine Biological Association	200	0	0
'Baths Committee,' Bath	100	0	0
	£1417	0	11

1890.

	£	s.	d.
Electrical Standards	12	17	0
Electrolysis	5	0	0
Electro-optics	50	0	0
Mathematical Tables	25	0	0
Volcanic and Seismological Phenomena of Japan	75	0	0
Pellian Equation Tables	15	0	0
Properties of Solutions	10	0	0
International Standard for the Analysis of Iron and Steel	10	0	0
Influence of the Silent Discharge of Electricity on Oxygen	5	0	0
Methods of teaching Chemistry	10	0	0
Recording Results of Water Analysis	4	1	0
Oxidation of Hydracids in Sunlight	15	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	10	0	0
Circulation of Underground Waters	5	0	0
Excavations at Oldbury Hill	15	0	0
Cretaceous Polyzoa	10	0	0
Geological Photographs	7	14	11
Lias Beds of Northampton	25	0	0
Botanical Station at Peradeniya	25	0	0

	£	s.	d.
Experiments with a Tow-net	4	3	9
Naples Zoological Station ...	100	0	0
Zoology and Botany of the West India Islands	100	0	0
Marine Biological Association	30	0	0
Action of Waves and Currents in Estuaries	150	0	0
Graphic Methods in Mechanical Science	11	0	0
Anthropometric Calculations	5	0	0
Nomad Tribes of Asia Minor	25	0	0
Corresponding Societies	20	0	0
	£799	16	8

1891.

	£	s.	d.
Ben Nevis Observatory	50	0	0
Electrical Standards	100	0	0
Electrolysis	5	0	0
Seismological Phenomena of Japan	10	0	0
Temperatures of Lakes	20	0	0
Photographs of Meteorological Phenomena	5	0	0
Discharge of Electricity from Points	10	0	0
Ultra Violet Rays of Solar Spectrum	50	0	0
International Standard for Analysis of Iron and Steel...	10	0	0
Isomeric Naphthalene Derivatives	25	0	0
Formation of Haloids	25	0	0
Action of Light on Dyes	17	10	0
Geological Record	100	0	0
Volcanic Phenomena of Vesuvius	10	0	0
Fossil Phyllopoda	10	0	0
Photographs of Geological Interest	9	5	0
Lias of Northamptonshire ...	25	0	0
Registration of Type-Specimens of British Fossils......	5	5	0
Investigation of Elbolton Cave	25	0	0
Botanical Station at Peradeniya	50	0	0
Experiments with a Tow-net	40	0	0
Marine Biological Association	12	10	0
Disappearance of Native Plants	5	0	0
Action of Waves and Currents in Estuaries	125	0	0
Anthropometric Calculations	10	0	0
New Edition of 'Anthropological Notes and Queries'	50	0	0
North-Western Tribes of Canada	200	0	0
Corresponding Societies	25	0	0
	£1,029	10	0

1892.

	£	s.	d.
Observations on Ben Nevis ...	50	0	0
Photographs of Meteorological Phenomena	15	0	0
Pellian Equation Tables	10	0	0
Discharge of Electricity from Points	50	0	0
Seismological Phenomena of Japan	10	0	0
Formation of Haloids	12	0	0
Properties of Solutions	10	0	0
Action of Light on Dyed Colours	10	0	0
Erratic Blocks	15	0	0
Photographs of Geological Interest	20	0	0
Underground Waters	10	0	0
Investigation of Elbolton Cave	25	0	0
Excavations at Oldbury Hill	10	0	0
Cretaceous Polyzoa	10	0	0
Naples Zoological Station ...	100	0	0
Marine Biological Association	17	10	0
Deep-sea Tow-net	40	0	0
Fauna of Sandwich Islands...	100	0	0
Zoology and Botany of West India Islands	100	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Anthropometric Laboratory...	5	0	0
Anthropological Notes and Queries	20	0	0
Prehistoric Remains in Mashonaland	50	0	0
North-Western Tribes of Canada	100	0	0
Corresponding Societies	25	0	0
	£864	10	0

1893.

	£	s.	d.
Electrical Standards	25	0	0
Observations on Ben Nevis ...	150	0	0
Mathematical Tables	15	0	0
Intensity of Solar Radiation	2	8	6
Magnetic Work at the Falmouth Observatory	25	0	0
Isomeric Naphthalene Derivatives	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	5	0	0
Underground Waters	5	0	0
Shell-bearing Deposits at Clava, Chapelhall, &c.	20	0	0
Eurypterids of the Pentland Hills	10	0	0
Naples Zoological Station ...	100	0	0
Marine Biological Association	30	0	0
Fauna of Sandwich Islands	100	0	0
Zoology and Botany of West India Islands	50	0	0

	£	s.	d.
Exploration of Irish Sea	30	0	0
Physiological Action of Oxygen in Asphyxia	20	0	0
Index of Genera and Species of Animals	20	0	0
Exploration of Karakoram Mountains	50	0	0
Scottish Place-names	7	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Economic Training	3	7	0
Anthropometric Laboratory	5	0	0
Exploration in Abyssinia	25	0	0
North-Western Tribes of Canada	100	0	0
Corresponding Societies	30	0	0
	£907	15	6

1894.

	£	s.	d.
Electrical Standards	25	0	0
Photographs of Meteorological Phenomena	10	0	0
Tables of Mathematical Functions	15	0	0
Intensity of Solar Radiation	5	5	6
Wave-length Tables	10	0	0
Action of Light upon Dyed Colours	5	0	0
Erratic Blocks	15	0	0
Fossil Phyllopoda	5	0	0
Shell-bearing Deposits at Clava, &c.	20	0	0
Eurypterids of the Pentland Hills	5	0	0
New Sections of Stonesfield Slate	14	0	0
Observations on Earth-tremors	50	0	0
Exploration of Calf-Hole Cave	5	0	0
Naples Zoological Station	100	0	0
Marine Biological Association	5	0	0
Zoology of the Sandwich Islands	100	0	0
Zoology of the Irish Sea	40	0	0
Structure and Function of the Mammalian Heart	10	0	0
Exploration in Abyssinia	30	0	0
Economic Training	9	10	0
Anthropometric Laboratory Statistics	5	0	0
Ethnographical Survey	10	0	0
The Lake Village at Glastonbury	40	0	0
Anthropometrical Measurements in Schools	5	0	0
Mental and Physical Condition of Children	20	0	0
Corresponding Societies	25	0	0
	£583	15	6

1895.

	£	s.	d.
Electrical Standards	25	0	0
Photographs of Meteorological Phenomena	10	0	0
Earth Tremors	75	0	0
Abstracts of Physical Papers	100	0	0
Reduction of Magnetic Observations made at Falmouth Observatory	50	0	0
Comparison of Magnetic Standards	25	0	0
Meteorological Observations on Ben Nevis	50	0	0
Wave-length Tables of the Spectra of the Elements	10	0	0
Action of Light upon Dyed Colours	4	6	1
Formation of Haloids from Pure Materials	20	0	0
Isomeric Naphthalene Derivatives	30	0	0
Electrolytic Quantitative Analysis	30	0	0
Erratic Blocks	10	0	0
Palæozoic Phyllopoda	5	0	0
Photographs of Geological Interest	10	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills	3	0	0
New Sections of Stonesfield Slate	50	0	0
Exploration of Calf Hole Cave	10	0	0
Nature and Probable Age of High-level Flint-drifts	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea	35	9	4
Zoology and Botany of the West India Islands	50	0	0
Index of Genera and Species of Animals	50	0	0
Climatology of Tropical Africa	5	0	0
Exploration of Hadramut	50	0	0
Calibration and Comparison of Measuring Instruments	25	0	0
Anthropometric Measurements in Schools	5	0	0
Lake Village at Glastonbury	30	0	0
Exploration of a Kitchen-midden at Hastings	10	0	0
Ethnographical Survey	10	0	0
Physiological Applications of the Phonograph	25	0	0
Corresponding Societies	30	0	0
	£977	15	5

1896.

	£	s.	d.
Photographs of Meteorological Phenomena	15	0	0
Seismological Observations	80	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Uniformity of Size of Pages of Transactions, &c.	5	0	0
Wave-length Tables of the Spectra of the Elements	10	0	0
Action of Light upon Dyed Colours	2	6	1
Electrolytic Quantitative Analysis	10	0	0
The Carbohydrates of Barley Straw	50	0	0
Reprinting Discussion on the Relation of Agriculture to Science	5	0	0
Erratic Blocks	10	0	0
Palæozoic Phyllopoda	5	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills	2	0	0
Investigation of a Coral Reef by Boring and Sounding	10	0	0
Examination of Locality where the Cetiosaurus in the Oxford Museum was found	25	0	0
Palæolithic Deposits at Hoxne	25	0	0
Fauna of Singapore Caves	40	0	0
Age and Relation of Rocks near Moreseat, Aberdeen	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea	50	0	0
Zoology of the Sandwich Islands	100	0	0
African Lake Fauna	100	0	0
Oysters under Normal and Abnormal Environment	40	0	0
Climatology of Tropical Africa	10	0	0
Calibration and Comparison of Measuring Instruments	20	0	0
Small Screw Gauge	10	0	0
North-Western Tribes of Canada	100	0	0
Lake Village at Glastonbury	30	0	0
Ethnographical Survey	40	0	0
Mental and Physical Condition of Children	10	0	0
Physiological Applications of the Phonograph	25	0	0
Corresponding Societies Committee	30	0	0
	£1,104	6	1

1897.

	£	s.	d.
Mathematical Tables	25	0	0
Seismological Observations	100	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Electrolysis and Electro-chemistry	50	0	0
Electrolytic Quantitative Analysis	10	0	0
Isomeric Naphthalene Derivatives	50	0	0
Erratic Blocks	10	0	0
Photographs of Geological Interest	15	0	0
Remains of the Irish Elk in the Isle of Man	15	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	9	10	8
Zoological Bibliography and Publication	5	0	0
Index Generum et Specierum Animalium	100	0	0
Zoology and Botany of the West India Islands	40	0	0
The Details of Observations on the Migration of Birds	40	0	0
Climatology of Tropical Africa	20	0	0
Ethnographical Survey	40	0	0
Mental and Physical Condition of Children	10	0	0
Silchester Excavation	20	0	0
Investigation of Changes associated with the Functional Activity of Nerve Cells and their Peripheral Extensions	180	0	0
Oysters and Typhoid	30	0	0
Physiological Applications of the Phonograph	15	0	0
Physiological Effects of Peptone and its Precursors	20	0	0
Fertilisation in Phæophyceæ	20	0	0
Corresponding Societies Committee	25	0	0
	£1,059	10	8

1898.

	£	s.	d.
Electrical Standards	75	0	0
Seismological Observations	75	0	0
Abstracts of Physical Papers	100	0	0
Calculation of certain Integrals	10	0	0
Electrolysis and Electro-chemistry	35	0	0
Meteorological Observatory at Montreal	50	0	0

	£	s.	d.
Wave-length Tables of the Spectra of the Elements	20	0	0
Action of Light upon Dyed Colours	8	0	0
Erratic Blocks	5	0	0
Investigation of a Coral Reef	40	0	0
Photographs of Geological Interest	10	0	0
Life-zones in British Carboniferous Rocks	15	0	0
Pleistocene Fauna and Flora in Canada	20	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	14	0	0
Index Generum et Specierum Animalium	100	0	0
Healthy and Unhealthy Oysters	30	0	0
Climatology of Tropical Africa	10	0	0
State Monopolies in other Countries	15	0	0
Small Screw Gauge	20	0	0
North-Western Tribes of Canada	75	0	0
Lake Village at Glastonbury	37	10	0
Silchester Excavation	7	10	0
Ethnological Survey of Canada	75	0	0
Anthropology and Natural History of Torres Straits	125	0	0
Investigation of Changes associated with the Functional Activity of Nerve Cells and their Peripheral Extensions	100	0	0
Fertilisation in Phæophyceæ	15	0	0
Corresponding Societies Committee	25	0	0
	£1,212	0	0

1899.

	£	s.	d.
Electrical Standards	225	0	0
Seismological Observations	65	14	8
Science Abstracts	100	0	0
Heat of Combination of Metals in Alloys	20	0	0
Radiation in a Magnetic Field	50	0	0
Calculation of certain Integrals	10	0	0
Action of Light upon Dyed Colours	4	19	6
Relation between Absorption Spectra and Constitution of Organic Substances	50	0	0
Erratic Blocks	15	0	0
Photographs of Geological Interest	10	0	0
Remains of Irish Elk in the Isle of Man	15	0	0
Pleistocene Flora and Fauna in Canada	30	0	0
Records of Disappearing Drift Section at Moel Tryfaen	5	0	0
Ty Newydd Caves	40	0	0
Ossiferous Caves at Uphill	30	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	100	0	0
Migration of Birds	15	0	0
Apparatus for Keeping Aquatic Organisms under Definite Physical Conditions	15	0	0
Plankton and Physical Conditions of the English Channel during 1899	100	0	0
Exploration of Sokotra	35	0	0
Lake Village at Glastonbury	50	0	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	35	0	0
New Edition of 'Anthropological Notes and Queries'	40	0	0
Age of Stone Circles	20	0	0
Physiological Effects of Peptone	30	0	0
Electrical Changes accompanying Discharge of Respiratory Centres	20	0	0
Influence of Drugs upon the Vascular Nervous System	10	0	0
Histological Changes in Nerve Cells	20	0	0
Micro-chemistry of Cells	40	0	0
Histology of Suprarenal Capsules	20	0	0
Comparative Histology of Cerebral Cortex	10	0	0
Fertilisation in Phæophyceæ	20	0	0
Assimilation in Plants	20	0	0
Zoological and Botanical Publication	5	0	0
Corresponding Societies Committee	25	0	0
	£1,430	14	2

1900.

	£	s.	d.
Electrical Standards	25	0	0
Seismological Observations	60	0	0
Radiation in a Magnetic Field	25	0	0
Meteorological Observatory at Montreal	20	0	0
Tables of Mathematical Functions	75	0	0
Relation between Absorption Spectra and Constitution of Organic Bodies	30	0	0
Wave-length Tables	5	0	0
Electrolytic Quantitative Analysis	5	0	0

	£	s.	d.
Isomorphous Sulphonic Derivatives of Benzene	20	0	0
The Nature of Alloys	30	0	0
Photographs of Geological Interest	10	0	0
Remains of Elk in the Isle of Man	5	0	0
Pleistocene Fauna and Flora in Canada	10	0	0
Movements of Underground Waters of Craven	40	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	50	0	0
Migration of Birds	15	0	0
Plankton and Physical Conditions of the English Channel	40	0	0
Zoology of the Sandwich Islands	100	0	0
Coral Reefs of the Indian Region	30	0	0
Physical and Chemical Constants of Sea-Water	100	0	0
Future Dealings in Raw Produce	2	10	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	50	0	0
New Edition of 'Anthropological Notes and Queries'	40	0	0
Photographs of Anthropological Interest	10	0	0
Mental and Physical Condition of Children in Schools	5	0	0
Ethnography of the Malay Peninsula	25	0	0
Physiological Effects of Peptone	20	0	0
Comparative Histology of Suprarenal Capsules	20	0	0
Comparative Histology of Cerebral Cortex	5	0	0
Electrical Changes in Mammalian Nerves	20	0	0
Vascular Supply of Secreting Glands	10	0	0
Fertilisation in Phæophyceæ	20	0	0
Corresp. Societies Committee	20	0	0
	£1,072	10	0

1901.

	£	s.	d.
Electrical Standards	45	0	0
Seismological Observations	75	0	0
Wave-length Tables	4	14	0
Isomorphous Sulphonic Derivatives of Benzene	35	0	0
Life-zones in British Carboniferous Rocks	20	0	0
Underground Water of North-west Yorkshire	50	0	0
Exploration of Irish Caves	15	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	75	0	0
Migration of Birds	10	0	0
Terrestrial Surface Waves	5	0	0
Changes of Land-level in the Phlegræan Fields	50	0	0
Legislation regulating Women's Labour	15	0	0
Small Screw Gauge	45	0	0
Resistance of Road Vehicles to Traction	75	0	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	30	0	0
Anthropological Teaching	5	0	0
Exploration in Crete	145	0	0
Physiological Effects of Peptone	30	0	0
Chemistry of Bone Marrow	5	15	11
Suprarenal Capsules in the Rabbit	5	0	0
Fertilisation in Phæophyceæ	15	0	0
Morphology, Ecology, and Taxonomy of Podostemaceæ	20	0	0
Corresponding Societies Committee	15	0	0
	£920	9	11

1902.

	£	s.	d.
Electrical Standards	40	0	0
Seismological Observations	35	0	0
Investigation of the Upper Atmosphere by means of Kites	75	0	0
Magnetic Observations at Falmouth	80	0	0
Relation between Absorption Spectra and Organic Substances	20	0	0
Wave-length Tables	5	0	0
Life-zones in British Carboniferous Rocks	10	0	0
Exploration of Irish Caves	45	0	0
Table at the Zoological Station, Naples	100	0	0
Index Generum et Specierum Animalium	100	0	0
Migration of Birds	15	0	0
Structure of Coral Reefs of Indian Ocean	50	0	0

	£	s.	d.
Compound Ascidians of the Clyde Area	25	0	0
Terrestrial Surface Waves	15	0	0
Legislation regulating Women's Labour	30	0	0
Small Screw Gauge	20	0	0
Resistance of Road Vehicles to Traction	50	0	0
Ethnological Survey of Canada	15	0	0
Age of Stone Circles	30	0	0
Exploration in Crete	100	0	0
Anthropometric Investigation of Native Egyptian Soldiers	15	0	0
Excavations on the Roman Site at Gelligaer	5	0	0
Changes in Hæmoglobin	15	0	0
Work of Mammalian Heart under Influence of Drugs	20	0	0
Investigation of the Cyanophyceæ	10	0	0
Reciprocal Influence of Universities and Schools	5	0	0
Conditions of Health essential to carrying on Work in Schools	2	0	0
Corresponding Societies Committee	15	0	0
	£947	0	0

General Meetings.

On Wednesday, September 10, at 8.30 P.M., in the Grosvenor Hall, Belfast, Principal Sir A. W. Rücker, M.A., D.Sc., F.R.S., resigned the office of President to Professor James Dewar, M.A., LL.D., D.Sc., F.R.S., who took the Chair, and delivered an Address, for which see page 3.

On Thursday, September 11, at 8 P.M., a Soirée took place in the Exhibition Hall.

On Friday, September 12, at 8.30 P.M., in the Grosvenor Hall, Professor J. J. Thomson, F.R.S., delivered a Discourse on 'Becquerel Rays and Radio-activity.'

On Monday, September 15, at 8.30 P.M., in the Grosvenor Hall, Professor W. F. R. Weldon, F.R.S., delivered a Discourse on 'Inheritance.'

On Tuesday, September 16, at 8 P.M., a Soirée took place at the Harbour Office.

On Wednesday, September 17, at 2.30 P.M., in Queen's College, the concluding General Meeting took place, when the Proceedings of the General Committee and the Grants of Money for Scientific Purposes were explained to the Members.

The Meeting was then adjourned to Southport. [The Meeting is appointed to commence on Wednesday, September 9, 1903.]

PRESIDENT'S ADDRESS.

ADDRESS

BY

Professor JAMES DEWAR, M.A., LL.D., D.Sc., F.R.S.

PRESIDENT.

The members of an Association whose studies involve perpetual contemplation of settled law and ordered evolution, whose objects are to seek patiently for the truth of things and to extend the dominion of man over the forces of nature, are even more deeply pledged than other men to loyalty to the Crown and the Constitution which procure for them the essential conditions of calm security and social stability. I am confident that I express the sentiments of all now before me when I say that to our loyal respect for his high office we add a warmer feeling of loyalty and attachment to the person of our Gracious Sovereign. It is the peculiar felicity of the British Association that, since its foundation seventy-one years ago, it has always been easy and natural to cherish both these sentiments, which indeed can never be dissociated without peril. At this, our second meeting held under the present reign, these sentiments are realised all the more vividly, because, in common with the whole empire, we have recently passed through a period of acute apprehension, followed by the uplifting of a national deliverance. The splendid and imposing coronation ceremony which took place just a month ago was rendered doubly impressive both for the King and his people by the universal consciousness that it was also a service of thanksgiving for escape from imminent peril. In offering to His Majesty our most hearty congratulations upon his singularly rapid recovery from a dangerous illness, we rejoice to think that the nation has received gratifying evidence of the vigour of his constitution, and may, with confidence more assured than before, pray that he may have length of happy and prosperous days. No one in his wide dominions is more competent than the King to realise how much he owes, not only to the skill of his surgeons, but also to the equipment which has been placed in their hands as the combined result of scientific investigation in many and diverse directions. He has already displayed a profound and sagacious interest in the discovery of methods for dealing with some of the most intractable maladies that still baffle scientific penetration; nor can we doubt that this interest extends to other forms of scientific investigation, more directly connected with the amelioration of the lot of the healthy than with the relief of the sick. Heredity imposes obligations and also confers aptitude for their discharge. If His Majesty's royal mother throughout her long and beneficent reign set him a splendid example of devotion to the burdensome labours of State which must necessarily absorb the chief part of his energies, his father no less clearly indicated the great part he may play in the encouragement of science. Intelligent appreciation of scientific work and needs is not less but more necessary in the highest quarters to-day than it was forty-three years ago, when His Royal Highness the Prince Consort brought the matter before this Association in the following memorable passage in his Presidential Address: 'We may be justified, however, in hoping that by the gradual diffusion of science and its increasing recognition as a principal part of our national education, the public in general, no less than the legislature and the State, will more and more recognise the claims of science to their attention; so that it may no longer require the begging box, but speak to the State like a favoured child to its parent, sure of his paternal solicitude for its welfare; that the State will recognise in science one of its elements of strength and prosperity, to protect which the clearest dictates of self-interest demand.' Had this advice been seriously taken to heart and acted upon by the rulers of the nation at the time, what splendid results would have accrued to this country! We should not now be painfully groping in the dark after a system of national education. We should not be wasting money, and time more valuable than money, in building imitations of foreign educational superstructures before having put in solid foundations. We should not be hurriedly and distractedly casting about for a system of tactics after confrontation with the disciplined and co-ordinated forces of industry and science led and directed by the rulers of powerful States. Forty-three years ago we should have started fair had the Prince Consort's views prevailed. As it is, we have lost ground which it will tax even this nation's splendid reserves of individual initiative to recover. Although in this country the king rules, but does not govern, the Constitution and the structure of English society assure to him a very potent and far-reaching influence upon those who do govern. It is hardly possible to overrate the benefits that may accrue from his intelligent and continuous interest in the great problem of transforming his people into a scientifically educated nation. From this point of view we may congratulate ourselves that the heir to the Crown, following his family traditions, has already deduced from his own observations in different parts of the empire some very sound and valuable conclusions as to the national needs at the present day.

Griffith—Gilbert—Cornu—Abel.

The saddest yet the most sacred duty falling to us on such an occasion as the present is to pay our tribute to the memory of old comrades and fellow-workers whom we shall meet no more. We miss to-day a figure that has been familiar, conspicuous, and always congenial at the meetings of the British Association during the last forty years. Throughout the greater part of that period Mr. George Griffith discharged the onerous and often delicate duties of the assistant general secretary, not only with conscientious thoroughness and great ability, but also with urbanity, tact, and courtesy that endeared him to all. His years sat lightly upon him, and his undiminished alertness and vigour caused his sudden death to come upon us all with a shock of surprise as well as of pain and grief. The British Association owes him a debt of gratitude which must be so fully realised by every regular attender of our meetings that no poor words of mine are needed to quicken your sense of loss, or to add to the poignancy of your regret.

The British Association has to deplore the loss from among us of Sir Joseph Gilbert, a veteran who continued to the end of a long life to pursue his important and beneficent researches with untiring energy. The length of his services in the cause of science cannot be better indicated than by recalling the fact that he was one of the six past Presidents boasting fifty years' membership whose jubilee was celebrated by the Chemical Society in 1898. He was in fact an active member of that Society for over sixty years. Early in his career he devoted himself to a most important but at that time little cultivated field of research. He strove with conspicuous success to place the oldest of industries on a scientific basis, and to submit the complex conditions of agriculture to a systematic analysis. He studied the physiology of plant life in the open air, not with the object of penetrating the secrets of structure, but with the more directly utilitarian aim of establishing the conditions of successful and profitable cultivation. By a long series of experiments alike well conceived and laboriously carried out, he determined the effects of variation in soil, and its chemical treatment—in short, in all the unknown factors with which the farmer previously had to deal according to empirical and local rules, roughly deduced from undigested experience by uncritical and rudimentary processes of inference. Gilbert had the faith, the insight, and the courage to devote his life to an investigation so difficult, so unpromising, and so unlikely to bring the rich rewards attainable by equal diligence in other directions, as to offer no attraction to the majority of men. The tabulated results of the Rothamsted experiments remain as a benefaction to mankind and a monument of indomitable and disinterested perseverance.

It is impossible for me in this place to offer more than the barest indication of the great place in contemporary science that has been vacated by the lamented death of Professor Alfred Cornu, who so worthily upheld the best traditions of scientific France. He was gifted in a high degree with the intellectual lucidity, the mastery of form, and the perspicuous method which characterise the best exponents of French thought in all departments of study. After a brilliant career as a student, he was chosen at the early age of twenty-six to fill one of the enviable positions more numerous in Paris than in London, the Professorship of Physics at the École Polytechnique. In that post, which he occupied to the end of his life, he found what is probably the ideal combination for a man of science—leisure and material equipment for original research, together with that close and stimulating contact with practical affairs afforded by his duties as teacher in a great school, almost ranking as a department of State. Cornu was admirable alike in the use he made of his opportunities and in his manner of discharging his duties. He was at once a great investigator and a great teacher. I shall not even attempt a summary, which at the best must be very imperfect, of his brilliant achievements in optics, the study of his predilection, in electricity, in acoustics, and in the field of physics generally. As a proof of the great estimation in which he was held, it is sufficient to remind you that he had filled the highest presidential offices in French scientific societies, and that he was a foreign member of our Royal Society and a recipient of its Rumford medal. In this country he had many friends, attracted no less by his personal and social qualities than by his commanding abilities. Some of those here present may remember his appearance a few years ago at the Royal Institution, and more recently his delivery of the Rede Lecture at Cambridge, when the University conferred upon him the honorary degree of Doctor of Science. His death has inflicted a heavy blow upon our generation, upon France, and upon the world.

[Since this address was written the Association has suffered a grievous loss through the sudden death of Sir Frederick Abel, a past President and one of the most representative and successful chemists of his generation. A distinguished pupil of Hoffmann, his early work was directed to the study of organic chemistry. His appointment as Chemist to the War Office at an early stage in his career directed his attention almost exclusively to problems dealing with the application of chemistry to naval and military questions ; a department of knowledge with which his name will always be identified. His researches on nitro-cellulose, detonation, and the history of explosive agents, contain many new and startling observations on the stability and utility of such agents for the purposes of war. His investigation, in association with Sir Andrew Noble, of the products of the decomposition of fired gunpowder has long been regarded as a classic. He had the satisfaction of living through the age of gunpowder, and of seeing those nitro-compounds of his earlier studies employed as smokeless propulsive agents. In contributing to our knowledge of the cause and prevention of colliery explosions and in devising a reliable flash-test for the examination of petroleum he did great public service. Further he made valuable contributions to the study of metallurgy, especially as regards the condition of the carbon in steel. We also owe to him a debt of gratitude for services rendered to scientific societies and to the cause of scientific education. His loss makes a serious vacancy in the ranks of English chemists.]

The Progress of Belfast.

A great man has observed that the 'intelligent anticipation of events before they occur' is a factor of some importance in human affairs. One may suppose that intelligent anticipation had something to do with the choice of Belfast as the meeting-place of the British Association this year. Or, if it had not, then it must be admitted that circumstances have conspired, as they occasionally do, to render the actual selection peculiarly felicitous. Belfast has perennial claims, of a kind that cannot easily be surpassed, to be the scene of a great scientific gathering—claims founded upon its scientific traditions and upon the conspicuous energy and success with which its citizens have prosecuted in various directions the application of science to the purposes of life. It is but the other day that the whole nation deplored at the grave of Lord Dufferin the loss of one of the most distinguished and most versatile public servants of the age. That great statesman and near neighbour of Belfast was a typical expression of the qualities and the spirit which have made Belfast what it is, and have enabled Ireland, in spite of all drawbacks, to play a great part in the Empire. I look round on your thriving and progressive city giving evidence of an enormous aggregate of industrial efforts intelligently organised and directed for the building up of a sound social fabric. I find that your great industries are interlinked and interwoven with the whole economic framework of the Empire, and that you are silently and irresistibly compelled to harmonious co-operation by practical considerations acting upon the whole community. It is here that I look for the real Ireland, the Ireland of the future. We cannot trace with precision the laws that govern the appearance of eminent men, but we may at least learn from history that they do not spring from every soil. They do not appear among decadent races or in ages of retrogression. They are the fine flower of the practical intellect of the nation working studiously and patiently in accordance with the great laws of conduct. In the manifold activities of Belfast we have a splendid manifestation of individual energy working necessarily, even if not altogether consciously, for the national good. In great Irishmen like Lord Dufferin and Lord Roberts, giving their best energies for the defence of the nation by diplomacy or by war, we have complementary evidence enough to reassure the most timid concerning the real direction of Irish energies and the vital nature of Irish solidarity with the rest of the Empire.

Belfast has played a prominent part in a transaction of a somewhat special and significant kind, which has proved not a little confusing and startling to the easy-going public. The significance of the shipping combination lies in the light it throws on the conditions and tendencies which make such things possible, if not even inevitable. It is an event forcibly illustrating the declaration of His Royal Highness the Prince of Wales, that the nation must 'wake up' if it hopes to face its growing responsibilities. Belfast may plead with some justice that it, at least, has never gone to sleep. In various directions an immense advance has been effected during the twenty-eight years that have elapsed since the last visit of the British Association. Belfast has become first a city and then a county, and now ranks as one of the eight largest cities in the United Kingdom. Its municipal area has been considerably extended, and its population has increased by something like 75 per cent. It has not only been extended, but improved and beautified in a manner which very few places can match, and which probably none can surpass. Fine new thoroughfares, adorned with admirable public institutions, have been run through areas once covered with crowded and squalid buildings. Compared with the early fifties, when iron shipbuilding was begun on a very modest scale, the customs collected at the port have increased tenfold. Since the introduction of the power-loom, about 1850, Belfast has distanced all rivals in the linen industry, which continues to flourish notwithstanding the fact that most of the raw material is now imported, instead of being produced, as in former times, in Ulster. Extensive improvements have been carried out in the port at a cost of several millions, and have been fully justified by a very great expansion of trade. These few bare facts suffice to indicate broadly the immense strides taken by Belfast in the last two decades. For an Association that exists for the advancement of science it is stimulating and encouraging to find itself in the midst of a vigorous community, successfully applying knowledge to the ultimate purpose of all human effort, the amelioration of the common lot by an ever-increasing mastery of the powers and resources of Nature.

Tyndall and Evolution.

The Presidential Address delivered by Tyndall in this city twenty-eight years ago will always rank as an epoch-making deliverance. Of all the men of the time, Tyndall was one of the best equipped for the presentation of a vast and complicated scientific subject to the mass of his fellow-men. Gifted with the powers of a many-sided original investigator, he had at the same time devoted much of his time to an earnest study of philosophy, and his literary and oratorical powers, coupled with a fine poetic instinct, were qualifications which placed him in the front rank of the scientific representatives of the later Victorian epoch, and constituted him an exceptionally endowed exponent of scientific thought. In the Belfast discourse Tyndall dealt with the changing aspects of the long unsettled horizon of human thought, at last illuminated by the sunrise of the doctrine of evolution. The consummate art with which he marshalled his scientific forces for the purpose of effecting conviction of the general truth of the doctrine has rarely been surpassed. The courage, the lucidity, the grasp of principles, the moral enthusiasm with which he treated his great theme, have powerfully aided in effecting a great intellectual conquest, and the victory assuredly ought to engender no regrets.

Tyndall's views as a strenuous supporter and believer in the theory of evolution were naturally essentially optimistic. He had no sympathy with the lugubrious pessimistic philosophy whose disciples are for ever intent on administering rebuke to scientific workers by reminding them that, however much knowledge man may have acquired, it is as nothing compared with the immensity of his ignorance. That truth is indeed never adequately realised except by the man of science, to whom it is brought home by repeated experience of the fact that his most promising excursions into the unknown are invariably terminated by barriers which, for the time at least, are insurmountable. He who has never made such excursions with patient labour may indeed prattle about the vastness of the unknown, but he does so without real sincerity or intimate conviction. His tacit, if not his avowed, contention is, that since we can never know all it is not worth while to seek to know more ; and that in the profundity of his ignorance he has the right to people the unexplored spaces with the phantoms of his vain imagining. The man of science, on the contrary, finds in the extent of his ignorance a perpetual incentive to further exertion, and in the mysteries that surround him a continual invitation, nay, more, an inexorable mandate. Tyndall's writings abundantly prove that he had faced the great problems of man's existence with that calm intellectual courage, the lack of which goes very far to explain the nervous dogmatism of nescience. Just because he had done this, because he had, as it were, mapped out the boundaries between what is knowable though not yet known and what must remain for ever unknowable to man, he did not hesitate to place implicit reliance on the progress of which man is capable, through the exercise of patient and persistent research. In Tyndall's scheme of thought the chief dicta were the strict division of the world of knowledge from that of emotion, and the lifting of life by throwing overboard the malign residuum of dogmatism, fanaticism, and intolerance, thereby stimulating and nourishing a plastic vigour of intellect. His cry was 'Commotion before stagnation, the leap of the torrent before the stillness of the swamp.'

His successors have no longer any need to repeat those significant words, 'We claim and we shall wrest from theology the entire domain of cosmological theory.' The claim has been practically, though often unconsciously, conceded. Tyndall's dictum, 'Every system must be plastic to the extent that the growth of knowledge demands,' struck a note that was too often absent from the heated discussions of days that now seem so strangely remote. His honourable admission that, after all that had been achieved by the developmental theory, 'the whole process of evolution is the manifestation of a power absolutely inscrutable to the intellect of man,' shows how willingly he acknowledged the necessary limits of scientific inquiry. This reservation did not prevent him from expressing the conviction forced upon him by the pressure of intellectual necessity, after exhaustive consideration of the known relations of living things, that matter in itself must be regarded as containing the promise and potency of all terrestrial life. Bacon in his day said very much the same thing: 'He that will know the properties and proceedings of matter should comprehend in his understanding the sum of all things, which have been, which are, and which shall be, although no knowledge can extend so far as to singular and individual beings.' Tyndall's conclusion was at the time thought to be based on a too insecure projection into the unknown, and some even regarded such an expansion of the crude properties of matter as totally unwarranted. Yet Tyndall was certainly no materialist in the ordinary acceptation of the term. It is true his arguments, like all arguments, were capable of being distorted, especially when taken out of their context, and the address became in this way an easy prey for hostile criticism. The glowing rhetoric that gave charm to his discourse and the poetic similes that clothed the dry bones of his close-woven logic were attacked by a veritable broadside of critical artillery. At the present day these would be considered as only appropriate artistic embellishments, so great is the unconscious change wrought in our surroundings. It must be remembered that, while Tyndall discussed the evolutionary problem from many points of view, he took up the position of a practical disciple of Nature dealing with the known experimental and observational realities of physical inquiry. Thus he accepted as fundamental concepts the atomic theory, together with the capacity of the atom to be the vehicle or repository of energy, and the grand generalisation of the conservation of energy. Without the former, Tyndall doubted whether it would be possible to frame a theory of the material universe; and as to the latter he recognised its radical significance in that the ultimate philosophical issues therein involved were as yet but dimly seen. That such generalisations are provisionally accepted does not mean that science is not alive to the possibility that what may now be regarded as fundamental may in future be superseded or absorbed by a wider generalisation. It is only the poverty of language and the necessity for compendious expression that oblige the man of science to resort to metaphor and to speak of the Laws of Nature. In reality, he does not pretend to formulate any laws for Nature, since to do so would be to assume a knowledge of the inscrutable cause from which alone such laws could emanate. When he speaks of a 'law of Nature' he simply indicates a sequence of events which, so far as his experience goes, is invariable, and which therefore enables him to predict, to a certain extent, what will happen in given circumstances. But, however seemingly bold may be the speculation in which he permits himself to indulge, he does not claim for his best hypothesis more than provisional validity. He does not forget that to-morrow may bring a new experience compelling him to recast the hypothesis of to-day. This plasticity of scientific thought, depending upon reverent recognition of the vastness of the unknown, is oddly made a matter of reproach by the very people who harp upon the limitations of human knowledge. Yet the essential condition of progress is that we should generalise to the best of our ability from the experience at command, treat our theory as provisionally true, endeavour to the best of our power to reconcile with it all the new facts we discover, and abandon or modify it when it ceases to afford a coherent explanation of new experience. That procedure is far as are the poles asunder from the presumptuous attempt to travel beyond the study of secondary causes. Any discussion as to whether matter or energy was the true reality would have appeared to Tyndall as a futile metaphysical disputation, which, being completely dissociated from verified experience, would lead to nothing. No explanation was attempted by him of the origin of the bodies we call elements, nor how some of such bodies came to be compounded into complex groupings and built up into special structures with which, so far as we know, the phenomena characteristic of life are invariably associated. The evolutionary doctrine leads us to the conclusion that life, such as we know it, has only been possible during a short period of the world's history, and seems equally destined to disappear in the remote future; but it postulates the existence of a material universe endowed with an infinity of powers and properties, the origin of which it does not pretend to account for. The enigma at both ends of the scale Tyndall admitted, and the futility of attempting to answer such questions he fully recognised. Nevertheless, Tyndall did not mean that the man of science should be debarred from speculating as to the possible nature of the simplest forms of matter or the mode in which life may have originated on this planet. Lord Kelvin, in his Presidential Address, put the position admirably when he said 'Science is bound by the everlasting law of honour to face fearlessly every problem that can fairly be presented to it. If a probable solution consistent with the ordinary course of Nature can be found, we must not invoke an abnormal act of Creative Power'; and in illustration he forthwith proceeded to express his conviction that from time immemorial many worlds of life besides our own have existed, and that 'it is not an unscientific hypothesis that life originated on this earth through the moss-grown fragments from the ruins of another world.' In spite of the great progress made in science, it is curious to notice the occasional recrudescence of metaphysical dogma. For instance, there is a school which does not hesitate to revive ancient mystifications in order to show that matter and energy can be shattered by philosophical arguments, and have no objective reality. Science is at once more humble and more reverent. She confesses her ignorance of the ultimate nature of matter, of the ultimate nature of energy, and still more of the origin and ultimate synthesis of the two. She is content with her patient investigation of secondary causes, and glad to know that since Tyndall spoke in Belfast she has made great additions to the knowledge of general molecular mechanism, and especially of synthetic artifice in the domain of organic chemistry, though the more exhaustive acquaintance gained only forces us the more to acquiesce in acknowledging the inscrutable mystery of matter. Our conception of the power and potency of matter has grown in little more than a quarter of a century to much more imposing dimensions, and the outlook for the future assuredly suggests the increasing acceleration of our rate of progress. For the impetus he gave to scientific work and thought, and for his fine series of researches chiefly directed to what Newton called the more secret and noble works of Nature within the corpuscules, the world owes Tyndall a debt of gratitude. It is well that his memory should be held in perennial respect, especially in the land of his birth.

The Endowment of Education.

These are days of munificent benefactions to science and education, which however are greater and more numerous in other countries than in our own. Splendid as they are, it may be doubted, if we take into account the change in the value of money, the enormous increase of population, and the utility of science to the builders of colossal fortunes, whether they bear comparison with the efforts of earlier days. But the habit of endowing science was so long in practical abeyance that every evidence of its resumption is matter for sincere congratulation. Mr. Cecil Rhodes has dedicated a very large sum of money to the advancement of education, though the means he has chosen are perhaps not the most effective. It must be remembered that his aims were political as much as educational. He had the noble and worthy ambition to promote enduring friendship between the great English-speaking communities of the world, and knowing the strength of college ties he conceived that this end might be greatly furthered by bringing together at an English university the men who would presumably have much to do in later life with the influencing of opinion, or even with the direction of policy. It has been held by some a striking tribute to Oxford that a man but little given to academic pursuits or modes of thought should think it a matter of high importance to bring men from our colonies or even from Germany, to submit to the formative influences of that ancient seat of learning. But this is perhaps reading Mr. Rhodes backwards. He showed his affectionate recollection of his college days by his gift to Oriel. But, apart from the main idea of fostering good relations between those who will presumably be influential in England, in the colonies, and in the United States, Mr Rhodes was probably influenced also by the hope that the influx of strangers would help to broaden Oxford notions and to procure revision of conventional arrangements.

Dr. Andrew Carnegie's endowment of Scottish universities, as modified by him in deference to expert advice, is a more direct benefit to the higher education. For while Mr. Rhodes has only enabled young men to get what Oxford has to give, Dr. Carnegie has also enabled his trustees powerfully to augment and improve the teaching equipment of the universities themselves. At the same time he has provided as far as possible for the enduring usefulness of his money. His trustees form a permanent body external to the universities, which, while possessing no power of direct control, must always, as holder of the purse-strings, be in a position to offer independent and weighty criticisms. More recently Dr. Carnegie has devoted an equal sum of ten million dollars to the foundation of a Carnegie Institution in Washington. Here again he has been guided by the same ideas. He has neither founded a university nor handed over the money to any existing university. He has created a permanent trust charged with the duty of watching educational efforts and helping them from the outside according to the best judgment that can be formed in the circumstances of the moment. Its aims are to be—to promote original research; to discover the exceptional man in every department of study, whether inside or outside of the schools, and to enable him to make his special study his life-work; to increase facilities for higher education; to aid and stimulate the universities and other educational institutions; to assist students who may prefer to study at Washington; and to ensure prompt publication of scientific discoveries. The general purpose of the founder is to secure, if possible, for the United States leadership in the domain of discovery and the utilisation of new forces for the benefit of man. Nothing will more powerfully further this end than attention to the injunction to lay hold of the exceptional man whenever and wherever he may be found, and, having got him, to enable him to carry on the work for which he seems specially designed. That means, I imagine, a scouring of the old world, as well as of the new, for the best men in every department of study—in fact, an assiduous collecting of brains similar to the collecting of rare books and works of art which Americans are now carrying on in so lavish a manner. As in diplomacy and war, so in science, we owe our reputation, and no small part of our prosperity, to exceptional men; and that we do not enjoy these things in fuller measure we owe to our lack of an army of well-trained ordinary men capable of utilising their ideas. Our exceptional men have too often worked in obscurity, without recognition from a public too imperfectly instructed to guess at their greatness, without assistance from a State governed largely by dialecticians, and without help from academic authorities hidebound by the pedantries of medieval scholasticism. For such men we have to wait upon the will of Heaven. Even Dr. Carnegie will not always find them when they are wanted. But what can be done in that direction will be done by institutions like Dr. Carnegie's, and for the benefit of the nation that possesses them in greatest abundance and uses them most intelligently. When contemplating these splendid endowments of learning, it occurred to me that it would be interesting to find out exactly what some definite quantity of scientific achievement has cost in hard cash. In an article by Carl Snyder in the January number of the 'North American Review,' entitled 'America's Inferior Place in the Scientific World,' I found the statement that 'it would be hardly too much to say that during the hundred years of its existence the Royal Institution alone has done more for English science than all of the English universities put together. This is certainly true with regard to British industry, for it was here that the discoveries of Faraday were made.' I was emboldened by this estimate from a distant and impartial observer to do, what otherwise

I might have shrunk from doing, and to take the Royal Institution—after all, the foundation of an American citizen, Count Rumford—as the basis of my inquiry. The work done at the Royal Institution during the past hundred years is a fairly definite quantity in the mind of every man really conversant with scientific affairs. I have obtained from the books accurate statistics of the total expenditure on experimental inquiry and public demonstrations for the whole of the nineteenth century. The items are :

	£
Professors' Salaries—Physics and Chemistry .	54,600
Laboratory Expenditure	24,430
Assistants' Salaries	21,590
Total for one hundred years . . .	£100,620

In addition, the members and friends of the Institution have contributed to a fund for exceptional expenditure for Experimental Research the sum of 9,580*l.* It should also be mentioned that a Civil List pension of 300*l.* was granted to Faraday in 1853, and was continued during twenty-seven years of active work and five years of retirement. Thirty-two years in all, at 300*l.* a year, make a sum of 9,600*l.*, representing the national donation, which, added to the amount of expenditure just stated, brings up the total cost of a century of scientific work in the laboratories of the Royal Institution, together with public demonstrations, to 119,800*l.*, or an average of 1,200*l.* per annum. I think if you recall the names and achievements of Young, Davy, Faraday, and Tyndall, you will come to the conclusion that the exceptional man is about the cheapest of natural products. It is a popular fallacy that the Royal Institution is handsomely endowed. On the contrary, it has often been in financial straits ; and since its foundation by Count Rumford its only considerable bequests have been one from Thomas G. Hodgkins, an American citizen, for Experimental Research, and that of John Fuller for endowing with 95*l.* a year the chairs of Chemistry and Physiology. In this connection the Davy-Faraday Laboratory, founded by the liberality of Dr. Ludwig Mond, will naturally occur to many minds. But though affiliated to the Royal Institution, with, I hope, reciprocal indirect advantages, that Laboratory is financially independent and its endowments are devoted to its own special purpose, which is to provide opportunity to prosecute independent research for worthy and approved applicants of all nationalities. The main reliance of the Royal Institution has always been, and still remains, upon the contributions of its members, and upon corresponding sacrifices in the form of time and labour by its professors. It may be doubted whether we can reasonably count upon a succession of scientific men able and willing to make sacrifices which the conditions of modern life tend to render increasingly burdensome. Modern science is in fact in something of a dilemma. Devotion to abstract research upon small means is becoming always harder to maintain, while at the same time the number of wealthy independent searchers after truth and patrons of science of the style of Joule, Spottiswoode, and De la Rue is apparently becoming smaller. The installations required by the refinements of modern science are continually becoming more costly, so that upon all grounds it would appear that without endowments of the kind provided by Dr. Carnegie the outlook for disinterested research is rather dark. On the other hand, these endowments, unless carefully administered, might obviously tend to impair the single-minded devotion to the search after truth for its own sake, to which science has owed almost every memorable advance made in the past. The Carnegie Institute will dispose in a year of as much money as the members of the Royal Institution have expended in a century upon its purely scientific work. It will at least be interesting to note how far the output of high-class scientific work corresponds to the hundredfold application of money to its production. Nor will it be of less interest to the people of this country to observe the results obtained from that moiety of Dr. Carnegie's gift to Scotland which is to be applied to the promotion of scientific research.

Applied Chemistry, English and Foreign.

The Diplomatic and Consular reports published from time to time by the Foreign Office are usually too belated to be of much use to business men, but they sometimes contain information concerning what is done in foreign countries which affords food for reflection. One of these reports, issued a year ago, gives a very good account of the German arrangements and provisions for scientific training, and of the enormous commercial demand for the services of men who have passed successfully through the universities and Technical High Schools, as well as of the wealth that has accrued to Germany through the systematic application of scientific proficiency to the ordinary business of life.

Taking these points in their order, I have thought it a matter of great interest to obtain a comparative view of chemical equipment in this country and in Germany, and I am indebted to Professor Henderson of Glasgow, who last year became the secretary of a committee of this Association of which Professor Armstrong is chairman, for statistics referring to this country, which enable a comparison to be broadly made. The author of the consular report estimates that in 1901 there were 4,500 trained chemists employed in German works, the number having risen to this point from 1,700 employed twenty-five years earlier. It is difficult to give perfectly accurate figures for this country, but a liberal estimate places the number of works chemists at 1,500, while at the very outside it cannot be put higher than somewhere between 1,500 and 2,000. In other words, we cannot show in the United Kingdom, notwithstanding the immense range of the chemical industries in which we once stood prominent, more than one-third of the professional staff employed in Germany. It may perhaps be thought or hoped that we make up in quality for our defect in quantity, but unfortunately this is not the case. On the contrary, the German chemists are, on the average, as superior in technical training and acquirements as they are numerically. Details are given in the report of the training of 633 chemists employed in German works. Of these, 69 per cent. hold the degree of Ph.D., about 10 per cent. hold the diploma of a Technical High School, and about 5 per cent. hold both qualifications. That is to say 84 per cent. have received a thoroughly systematic and complete chemical training, and 74 per cent. of these add the advantages of a university career. Compare with this the information furnished by 500 chemists in British works. Of these only 21 per cent. are graduates, while about 10 per cent. hold the diploma of a college. Putting the case as high as we can, and ignoring the more practical and thorough training of the German universities, which give their degrees for work done, and not for questions asked and answered on paper, we have only 31 per cent. of systematically trained chemists against 84 per cent. in German works. It ought to be mentioned that about 21 per cent. of the 500 are Fellows or Associates of the Institute of Chemistry, whatever that may amount to in practice, but of these a very large number have already been accounted for under the heads of graduates and holders of diplomas. These figures, which I suspect are much too favourable on the British side, unmistakably point to the prevalence among employers in this country of the antiquated adherence to rule of thumb, which is at the root of much of the backwardness we have to deplore. It hardly needs to be pointed out to such an audience as the present that chemists who are neither graduates of a university, nor holders of a diploma from a technical college, may be competent to carry on existing processes according to traditional methods, but are very unlikely to effect substantial improvements, or to invent new and more efficient processes. I am very far from denying that here and there an individual may be found whose exceptional ability enables him to triumph over all defects of training. But in all educational matters it is the average man whom we have to consider, and the average ability which we have to develop. Now, to take the second point—the actual money value of the industries carried on in Germany by an army of workers both quantitatively and qualitatively so superior to our own. The Consular report estimates the whole value of German chemical industries at not less than fifty millions sterling per annum. These industries have sprung up within the last seventy years, and have received enormous expansion during the last thirty. They are, moreover, very largely founded upon basic discoveries made by English chemists, but never properly appreciated or scientifically developed in the land of their birth. I will place before you some figures showing the growth of a single firm engaged in a single one of these industries—the utilisation of coal tar for the production of drugs, perfumes, and colouring-matters of every conceivable shade. The firm of Friedrich Bayer & Co. employed in 1875, 119 workmen. The number has more than doubled itself every five years, and in May of this year that firm employed 5,000 workmen, 160 chemists, 260 engineers and mechanics, and 680 clerks. For many years past it has regularly paid 18 per cent. on the ordinary shares, which this year has risen to 20 per cent. ; and in addition, in common with other and even larger concerns in the same industry, has paid out of profits for immense extensions usually charged to capital account. There is one of these factories, the works and plant of which stand in the books at 1,500,000*l.*, while the money actually sunk in them approaches to 5,000,000*l.* In other words, the practical monopoly enjoyed by the German manufacturers enables them to exact huge profits from the rest of the world, and to establish a position which, financially as well as scientifically, is almost unassailable. I must repeat that the fundamental discoveries upon which this gigantic industry is built were made in this country, and were practically developed to a certain extent by their authors. But in spite of the abundance and cheapness of the raw material, and in spite of the evidence that it could be most remuneratively worked up, these men founded no school and had practically no successors. The colours they made were driven out of the field by newer and better colours made from their stuff by the development of their ideas, but these improved colours were made in Germany and not in England. Now what is the explanation of this extraordinary and disastrous phenomenon ? I give it in a word—want of education. We had the material in abundance when other nations had comparatively little. We had the capital, and we had the brains, for we originated the whole thing. But we did not possess the diffused education without which the ideas of men of genius cannot fructify beyond the limited scope of an individual. I am aware that our patent laws are sometimes held responsible. Well, they are a contributory cause ; but it must be remembered that other nations with patent laws as protective as could be desired have not developed the colour industry. The patent laws have only contributed in a secondary degree, and if the patent laws have been bad the reason for their badness is again want of education. Make them as bad as you choose, and you only prove that the men who made them, and the public whom these men try to please, were misled by theories instead of being conversant with fact and logic. But the root of the mischief is not in the patent laws or in any legislation whatever. It is in the want of education among our so-called educated classes, and secondarily among the workmen on whom these depend. It is in the abundance of men of ordinary plodding ability, thoroughly trained and methodically directed, that Germany at present has so commanding an advantage. It is the failure of our schools to turn out, and of our manufacturers to demand, men of this kind, which explains our loss of some valuable industries and our precarious hold upon others. Let no one imagine for a moment that this deficiency can be remedied by any amount of that technical training which is now the fashionable nostrum. It is an excellent thing, no doubt, but it must rest upon a foundation of general training. Mental habits are formed for good or evil long before men go to the technical schools. We have to begin at the beginning : we have to train the population from the first to think correctly and logically, to deal at first hand with facts, and to evolve, each one for himself, the solution of a problem put before him, instead of learning by rote the solution given by somebody else. There are plenty of chemists turned out, even by our Universities, who would be of no use to Bayer & Co. They are chockfull of formulæ, they can recite theories, and they know text-books by heart ; but put them to solve a new problem, freshly arisen in the laboratory, and you will find that their learning is all dead. It has not become a vital part of their mental equipment, and they are floored by the first emergence of the unexpected. The men who escape this mental barrenness are men who were somehow or other taught to think long before they went to the university. To my mind, the really appalling thing is not that the Germans have seized this or the other industry, or even that they may have seized upon a dozen industries. It is that the German population has reached a point of general training and specialised equipment which it will take us two generations of hard and intelligently directed educational work to attain. It is that Germany possesses a national weapon of precision which must give her an enormous initial advantage in any and every contest depending upon disciplined and methodised intellect.

History of Cold and the Absolute Zero.

It was Tyndall's good fortune to appear before you at a moment when a fruitful and comprehensive idea was vivifying the whole domain of scientific thought. At the present time no such broad generalisation presents itself for discussion, while on the other hand the number of specialised studies has enormously increased. Science is advancing in so broad a front by the efforts of so great an army of workers that it would be idle to attempt within the limits of an address to the most indulgent of audiences anything like a survey of chemistry alone. But I have thought it might be instructive, and perhaps not uninteresting, to trace briefly in broad outline the development of that branch of study with which my own labours have been recently more intimately connected—a study which I trust I am not too partial in thinking is as full of philosophical interest as of experimental difficulty. The nature of heat and cold must have engaged thinking men from the very earliest dawn of speculation upon the external world ; but it will suffice for the present purpose if, disregarding ancient philosophers and even medieval alchemists, we take up the subject where it stood after the great revival of learning, and as it was regarded by the father of the inductive method. That this was an especially attractive subject to Bacon is evident from the frequency with which he recurs to it in his different works, always with lamentation over the inadequacy of the means at disposal for obtaining a considerable degree of cold. Thus in the chapter in the Natural History, 'Sylva Sylvarum,' entitled 'Experiments in consort touching the production of cold,' he says, 'The production of cold is a thing very worthy of the inquisition both for the use and the disclosure of causes. For heat and cold are nature's two hands whereby she chiefly worketh, and heat we have in readiness in respect of the fire, but for cold we must stay till it cometh or seek it in deep caves or high mountains, and when all is done we cannot obtain it in any great degree, for furnaces of fire are far hotter than a summer sun, but vaults and hills are not much colder than a winter's frost.' The great Robert Boyle was the first experimentalist who followed up Bacon's suggestions. In 1682 Boyle read a paper to the Royal Society on 'New Experiments and Observations touching Cold, or an Experimental History of Cold,' published two years later in a separate work. This is really a most complete history of everything known about cold up to that date, but its great merit is the inclusion of numerous experiments made by Boyle himself on frigorific mixtures, and the general effects of such upon matter. The agency chiefly used by Boyle in the conduct of his experiments was the glaciating mixture of snow or ice and salt. In the course of his experiments he made many important observations. Thus he observed that the salts which did not help the snow or ice to dissolve faster gave no effective freezing. He showed that water in becoming ice expands by about one-ninth of its volume, and bursts gun-barrels. He attempted to counteract the expansion and prevent freezing by completely filling a strong iron ball with water before cooling; anticipating that it might burst the bottle by the stupendous force of expansion, or that if it did not, then the ice produced might under the circumstances be heavier than water. He speculated in an ingenious way on the change of water into ice. Thus he says, 'If cold be but a privation of heat through the recess of that ethereal substance which agitated the little eel-like particles of the water and thereby made them compose a fluid body, it may easily be conceived that they should remain rigid in the postures in which the ethereal substance quitted them, and thereby compose an unfluid body like ice; yet how these little eels should by that recess acquire as strong an endeavour outwards as if they were so many little springs and expand themselves with so stupendous a force, is that which does not so readily appear.' The greatest degree of adventitious cold Boyle was able to produce did not make air exposed to its action lose a full tenth of its own volume, so that, in his own words, the cold does not 'weaken the spring by anything near so considerable as one would expect.' After making this remarkable observation and commenting upon its unexpected nature, it is strange Boyle did not follow it up. He questions the existence of a body of its own nature supremely cold, by participating in which all other bodies obtain that quality, although the doctrine of a *primum frigidum* had been accepted by many sects of philosophers; for, as he says, 'if a body being cold signify no more than its not having its sensible parts so much agitated as those of our sensorium, it suffices that the sun or the fire or some other agent, whatever it were, that agitated more vehemently its parts before, does either now cease to agitate them or agitates them but very remissly, so that till it be determined whether cold be a positive quality or but a privative it will be needless to contend what particular body ought to be esteemed the *primum frigidum.*' The whole elaborate investigation cost Boyle immense labour, and he confesses that he 'never handled any part of natural philosophy that was so troublesome and full of hardships.' He looked upon his results but as a 'beginning' in this field of inquiry, and for all the trouble and patience expended he consoled himself with the thought of 'men being oftentimes obliged to suffer as much wet and cold and dive as deep to fetch up sponges as to fetch up pearls.' After the masterly essay of Boyle, the attention of investigators was chiefly directed to improving thermometrical instruments. The old air thermometer of Galileo being inconvenient to use, the introduction of fluid thermometers greatly aided the inquiry into the action of heat and cold. For a time great difficulty was encountered in selecting proper fixed points on the scales of such instruments, and this stimulated men like Huygens, Newton, Hooke, and Amontons to suggest remedies and to conduct experiments. By the beginning of the eighteenth century the freezing-point and the boiling-point of water were agreed upon as fixed points, and the only apparent difficulties to be overcome were the selection of the fluid, accurate calibration of the capillary tube of the thermometer, and a general understanding as to scale divisions. It must be confessed that great confusion and inaccuracy in temperature observations arose from the variety and crudeness of the instruments. This led Amontons in 1702-3 to contribute two papers to the French Academy which reveal great originality in the handling of the subject, and which, strange to say, are not generally known. The first discourse deals with some new properties of the air and the means of accurately ascertaining the temperature in any climate. He regarded heat as due to a movement of the particles of bodies, though he did not in any way specify the nature of the motion involved; and as the general cause of all terrestrial motion, so that in its absence the earth would be without movement in its smallest parts. The new facts he records are observations on the spring or pressure of air brought about by the action of heat. He shows that different masses of air measured at the same initial spring or pressure, when heated to the boiling-point of water, acquire equal increments of spring or pressure, provided the volume of the gas be kept at its initial value. Further, he proves that if the pressure of the gas before heating be doubled or tripled, then the additional spring or pressure resulting from heating to the boiling-point of water is equally doubled or tripled. In other words, the ratio of the total spring of air at two definite and steady temperatures and at constant volume is a constant, independent of the mass or the initial pressure of the air in the thermometer. These results led to the increased perfection of the air thermometer as a standard instrument, Amontons' idea being to express the temperature at any locality in fractions of the degree of heat of boiling water. The great novelty of the instrument is that temperature is defined by the measurement of the length of a column of mercury. In passing, he remarks that we do not know the extreme of heat and cold, but that he has given the results of experiments which establish correspondences for those who wish to consider the subject. In the following year Amontons contributed to the Academy a further paper extending the scope of the inquiry. He there pointed out more explicitly that as the degrees of heat in his thermometer are registered by the height of a column of mercury, which the heat is able to sustain by the spring of the air, it follows that the extreme cold of the thermometer will be that which reduces the air to have no power of spring. This, he says, will be a much greater cold than what we call 'very cold,' because experiments have shown that if the spring of the air at boiling-point is 73 inches, the degree of heat which remains in the air when brought to the freezing-point of water is still very great, for it can still maintain the spring of 51½ inches. The greatest climatic cold on the scale of units adopted by Amontons is marked 50, and the greatest summer heat 58, the value for boiling water being 73, and the zero being 52 units below the freezing-point. Thus Amontons was the first to recognise that the use of air as a thermometric substance led to the inference of the existence of a zero of temperature, and his scale is nothing else than the absolute one we are now so familiar with. It results from Amontons' experiments that the air would have no spring left if it were cooled below the freezing-point of water to about 2½ times the temperature range which separates the boiling-point and the freezing-point. In other words, if we adopt the usual centessimal difference between these two points of temperature as 100 degrees, then the zero of Amontons' air thermometer is *minus* 240 degrees. This is a remarkable approximation to our modern value for the same point of *minus* 273 degrees. It has to be confessed that Amontons' valuable contributions to knowledge met with that fate which has so often for a time overtaken the work of too-advanced discoverers; in other words, it was simply ignored, or in any case not appreciated by the scientific world either of that time or half a century later. It was not till Lambert, in his work on 'Pyrometrie' published in 1779, repeated Amontons' experiments and endorsed his results that we find any further reference to the absolute scale or the zero of temperature. Lambert's observations were made with the greatest care and refinement, and resulted in correcting the value of the zero of the air scale to *minus* 270 degrees as compared with Amontons' *minus* 240 degrees. Lambert points out that the degree of temperature which is equal to zero is what one may call absolute cold, and that at this temperature the volume of the air would be practically nothing. In other words, the particles of the air would fall together and touch each other and become dense like water; and from this it may be inferred that the gaseous condition is caused by heat. Lambert says that Amontons' discoveries had found few adherents because they were too beautiful and advanced for the time in which he lived.

About this time a remarkable observation was made by Professor Braun at Moscow, who, during the severe winter of 1759, succeeded in freezing mercury by the use of a mixture of snow and nitric acid. When we remember that mercury was regarded as quite a peculiar substance possessed of the essential quality of fluidity, we can easily understand the universal interest created by the experiment of Braun. This was accentuated by the observations he made on the temperature given by the mercury thermometer, which appeared to record a temperature as low as *minus* 200° C. The experiments were soon repeated by Hutchins at Hudson's Bay, who conducted his work with the aid of suggestions given him by Cavendish and Black. The result of the new observations was to show that the freezing-point of mercury is only *minus* 40° C., the errors in former experiments having been due to the great contraction of the mercury in the thermometer in passing into the solid state. From this it followed that the enormous natural and artificial colds which had generally been believed in had no proved existence. Still the possible existence of a zero of temperature very different from that deduced from gas thermometry had the support of such distinguished names as those of Laplace and Lavoisier. In their great memoir on 'Heat,' after making what they consider reasonable hypotheses as to the relation between specific heat and total heat, they calculate values for the zero which range from 1,500 to 3,000 degrees below melting ice. On the whole, they regard the absolute zero as being in any case 600 degrees below the freezing-point. Lavoisier, in his 'Elements of Chemistry' published in 1792, goes further in the direction of indefinitely lowering the zero of temperature when he says, 'We are still very far from being able to produce the degree of absolute cold, or total deprivation of heat, being unacquainted with any degree of coldness which we cannot suppose capable of still further augmentation; hence it follows we are incapable of causing the ultimate particles of bodies to approach each other as near as possible, and thus these particles do not touch each other in any state hitherto known.' Even as late as the beginning of the nineteenth century we find Dalton, in his new system of 'Chemical Philosophy,' giving ten calculations of this value, and adopting finally as the natural zero of temperature *minus* 3,000° C.

In Black's lectures we find that he takes a very cautious view with regard to the zero of temperature, but as usual is admirably clear with regard to its exposition. Thus he says, 'We are ignorant of the lowest possible degree or beginning of heat. Some ingenious attempts have been made to estimate what it may be, but they have not proved satisfactory. Our knowledge of the degrees of heat may be compared to what we should have of a chain, the two ends of which were hidden from us and the middle only exposed to our view. We might put distinct marks on some of the links, and number the rest according as they are nearest to or further removed from the principal links; but not knowing the distance of any links from the end of the chain we could not compare them together with respect to their distance, or say that one link was twice as far from the end of the chain as another.' It is interesting to observe, however, that Black was evidently well acquainted with the work of Amontons, and strongly supports his inference as to the nature of air. Thus, in discussing the general cause of vaporisation, Black says that some philosophers have adopted the view 'that every palpable elastic fluid in nature is produced and preserved in this form by the action of heat. Mr. Amontons, an ingenious member of the late Royal Academy of Sciences, at Paris, was the first who proposed this idea with respect to the atmosphere. He supposed that it might be deprived of the whole of its elasticity and condensed and even frozen into a solid matter were it in our power to apply to it a sufficient cold; that it is a substance that differs from others by being incomparably more volatile, and which is therefore converted into vapour and preserved in that form by a weaker heat than any that ever happened or can obtain in this globe, and which therefore cannot appear under any other form than the one it now wears, so long as the constitution of the world remains the same as at present.' The views that Black attributes to Amontons have been generally associated with the name of Lavoisier, who practically admitted similar possibilities as to the nature of air; but it is not likely that in such matters Black would commit any mistake as to the real author of a particular idea, especially in his own department of knowledge. Black's own special contribution to low-temperature studies was his explanation of the interaction of mixtures of ice with salts and acids by applying the doctrine of the latent heat of fluidity of ice to account for the frigorific effect. In a similar way Black explained the origin of the cold produced in Cullen's remarkable experiment of the evaporation of ether under the receiver of an air-pump by pointing out that the latent heat of vaporisation in this case necessitated such a result. Thus, by applying his own discoveries to latent heat, Black gave an intelligent explanation of the cause of all the low-temperature phenomena known in his day.

After the gaseous laws had been definitely formulated by Gay-Lussac and Dalton, the question of the absolute zero of temperature, as deduced from the properties of gases, was revived by Clement and Desormes. These distinguished investigators presented a paper on the subject to the French Academy in 1812, which, it appears, was rejected by that body. The authors subsequently elected to publish it in 1819. Relying on what we know now to have been a faulty hypothesis, they deduced from observations on the heating of air rushing into a vacuum the temperature of *minus* 267 degrees as that of the absolute zero. They further endeavoured to show, by extending to lower temperatures the volume or the pressure coefficients of gases given by Gay-Lussac, that at the same temperature of *minus* 267 degrees the gases would contract so as to possess no appreciable volume, or, alternatively, if the pressure was under consideration, it would become so small as to be non-existent. Although full reference is given to previous work bearing on the same subject, yet, curiously enough, no mention is made of the name of Amontons. It certainly gave remarkable support to Amontons' notion of the zero to find that simple gases like hydrogen and compound gases like ammonia, hydrochloric, carbonic, and sulphurous acids should all point to substantially the same value for this temperature. But the most curious fact about this research of Clement and Desormes is that Gay-Lussac was a bitter opponent of the validity of the inferences they drew either from his work or their own. The mode in which Gay-Lussac regarded the subject may be succinctly put as follows: A quick compression of air to one-fifth volume raises its temperature to 300 degrees, and if this could be made much greater and instantaneous the temperature might rise to 1,000 or 2,000 degrees. Conversely, if air under five atmospheres were suddenly dilated, it would absorb as much heat as it had evolved during compression, and its temperature would be lowered by 300 degrees. Therefore, if air were taken and compressed to fifty atmospheres or more, the cold produced by its sudden expansion would have no limit. In order to meet this position Clement and Desormes adopted the following reasoning: They pointed out that it had not been proved that Gay-Lussac was correct in his hypothesis, but that in any case it tacitly involves the assumption that a limited quantity of matter possesses an unlimited supply of heat. If this were the case, then heat would be unlike any other measurable thing or quality. It is, therefore, more consistent with the course of nature to suppose that the amount of heat in a body is like the quantity of elastic fluid filling a vessel, which, while definite in original amount, one may make less and less by getting nearer to a complete exhaustion. Further, to realise the absolute zero in the one case is just as impossible as to realise the absolute vacuum in the other; and as we do not doubt a zero of pressure, although it is unattainable, for the same reason we ought to accept the reality of the absolute zero. We know now that Gay-Lussac was wrong in supposing the increment of temperature arising from a given gaseous compression would produce a corresponding decrement from an identical expansion. After this time the zero of temperature was generally recognised as a fixed ideal point, but in order to show that it was hypothetical a distinction was drawn between the use of the expressions, zero of absolute temperature and the absolute zero.

The whole question took an entirely new form when Lord Kelvin, in 1848, after the mechanical equivalent of heat had been determined by Joule, drew attention to the great principles underlying Carnot's work on the 'Motive Power of Heat,' and applied them to an absolute method of temperature measurement, which is completely independent of the properties of any particular substance. The principle was that for a difference of one degree on this scale, between the temperatures of the source and refrigerator, a perfect engine should give the same amount of work in every part of the scale. Taking the same fixed points as for the Centigrade scale, and making 100 of the new degrees cover that range, it was found that the degrees not only within that range, but as far beyond as experimental data supplied the means of comparison, differed by only minute quantities from those of Regnault's air thermometer. The zero of the new scale had to be determined by the consideration that when the refrigerator was at the zero of temperature the perfect engine should give an amount of work equal to the full mechanical equivalent of the heat taken up. This led to a zero of 273 degrees below the temperature of freezing water, substantially the same as that deduced from a study of the gaseous state. It was a great advance to demonstrate by the application of the laws of thermodynamics not only that the zero of temperature is a reality, but that it must be located at 273 degrees below the freezing-point of water. As no one has attempted to impugn the solid foundation of theory and experiment on which Lord Kelvin based his thermodynamic scale, the existence of a definite zero of temperature must be acknowledged as a fundamental scientific fact.

Liquefaction of Gases and Continuity of State.

In these speculations, however, chemists were dealing theoretically with temperatures to which they could not make any but the most distant experimental approach. Cullen, the teacher of Black, had indeed shown how to lower temperature by the evaporation of volatile bodies, such as ether, by the aid of the air-pump, and the later experiments of Leslie and Wollaston extended the same principle. Davy and Faraday made the most of the means at command in liquefying the more condensable gases, while at the same time Davy pointed out that they in turn might be utilised to procure greater cold by their rapid reconversion into the aeriform state. Still the chemist was sorely hampered by the want of some powerful and accessible agent for the production of temperatures much lower than had ever been attained. That want was supplied by Thilorier, who in 1835 produced liquid carbonic acid in large quantities, and further made the fortunate discovery that the liquid could be frozen into a snow by its own evaporation. Faraday was prompt to take advantage of this new and potent agent. Under exhaustion he lowered its boiling-point from *minus* 78° C. to *minus* 110° C., and by combining this low temperature with pressure all the gases were liquefied by the year 1844, with the exception of the three elementary gases—hydrogen, nitrogen, and oxygen, and three compound gases—carbonic oxide, marsh gas, and nitric oxide; Andrews some twenty-five years after the work of Faraday attempted to induce change of state in the uncondensed gases by using much higher pressures than Faraday employed. Combining the temperature of a solid carbonic acid bath with pressures of 300 atmospheres, Andrews found that none of these gases exhibited any appearance of liquefaction in such high states of condensation; but so far as change of volume by high compression went, Andrews confirmed the earlier work of Natterer by showing that the gases become proportionately less compressible with growing pressure. While such investigations were proceeding, Regnault and Magnus had completed their refined investigations on the laws of Boyle and Gay-Lussac. A very important series of experiments was made by Joule and Kelvin 'On the Thermal Effects of Fluids in Motion' about 1862, in which the thermometrical effects of passing gases under compression through porous plugs furnished important data for the study of the mutual action of the gas molecules. No one, however, had attempted to make a complete study of a liquefiable gas throughout wide ranges of temperature. This was accomplished by Andrews in 1869, and his Bakerian Lecture 'On the Continuity of the Gaseous and Liquid States of Matter' will always be regarded as an epoch-making investigation. During the course of this research Andrews observed that liquid carbonic acid raised to a temperature of 31° C. lost the sharp concave surface of demarcation between the liquid and the gas, the space being now occupied by a homogeneous fluid which exhibited, when the pressure was suddenly diminished or the temperature slightly lowered, a peculiar appearance of moving or flickering striæ, due to great local alterations of density. At temperatures above 31° C. the separation into two distinct kinds of matter could not be effected even when the pressure reached 400 atmospheres. This limiting temperature of the change of state from gas to liquid Andrews called the critical temperature. He showed that this temperature is constant, and differs with each substance, and that it is always associated with a definite pressure peculiar to each body. Thus the two constants, critical temperature and pressure, which have been of the greatest importance in subsequent investigations, came to be defined, and a complete experimental proof was given that 'the gaseous and liquid states are only distinct stages of the same condition of matter and are capable of passing into one another by a process of continuous change.'

In 1873 an essay 'On the Continuity of the Gaseous and Liquid State,' full of new and suggestive ideas, was published by van der Waals, who, recognising the value of Clausius' new conception of the Virial in Dynamics, for a long-continued series of motions, either oscillatory or changing exceedingly slowly with time, applied it to the consideration of the molecular movements of the particles of the gaseous substance, and after much refined investigation, and the fullest experimental calculation available at the time, devised his well-known Equation of Continuity. Its paramount merit is that it is based entirely on a mechanical foundation, and is in no sense empiric; we may therefore look upon it as having a secure foundation in fact, but as being capable of extension and improvement. James Thomson, realising that the straight-line breach of continuous curvature in the Andrews isothermals was untenable to the physical mind, propounded his emendation of the Andrews curves—namely, that they were continuous and of S form. We also owe to James Thomson the conception and execution of a three-dimensional model of Andrews' results, which has been of the greatest service in exhibiting the three variables by means of a specific surface afterwards greatly extended and developed by Professor

Willard Gibbs. The suggestive work of James Thomson undoubtedly was a valuable aid to van der Waals, for as soon as he reached the point where his equation had to show the continuity of the two states this was the first difficulty he had to encounter, and he succeeded in giving the explanation. He also gave a satisfactory reason for the existence of a minimum value of the product of volume and pressure in the Regnault isothermals. His isothermals, with James Thomson's completion of them, were now shown to be the results of the laws of dynamics. Van der Waals applied the new equation to the consideration of the coefficients of expansion with temperature and of pressure with temperature, showing that although they were nearly equal, nevertheless they were almost independent quantities. His investigation of the capillarity constant was masterly, and he added further to our knowledge of the magnitudes of the molecules of gases and of their mean free paths. Following up the experiments of Joule and Kelvin, he showed how their cooling coefficients could be deduced, and proved that they vanished at a temperature in each case which is a constant multiple of the specific critical temperature. The equation of continuity developed by van der Waals involved the use of three constants instead of one, as in the old law of Boyle and Charles, the latter being only utilised to express the relation of temperature, pressure, and volume, when the gas is far removed from its point of liquefaction. Of the two new constants one represents the molecular pressure arising from the attraction between the molecules, the other four times the volume of the molecules. Given these constants of a gas, van der Waals showed that his equation not only fitted into the general characters of the isothermals, but also gave the values of the critical temperature, the critical pressure, and the critical volume. In the case of carbonic acid the theoretical results were found to be in remarkable agreement with the experimental values of Andrews. This gave chemists the means of ascertaining the critical constants, provided sufficiently accurate data derived from the study of a few properly distributed isothermals of the gaseous substance were available. Such important data came into the possession of chemists when Amagat published his valuable paper on 'The Isothermals of Hydrogen, Nitrogen, Oxygen, Ethylene, &c.,' in the year 1880. It now became possible to calculate the critical data with comparative accuracy for the so-called permanent gases oxygen and nitrogen, and this was done by Sarrau in 1882. In the meantime a great impulse had been given to a further attack upon the so-called permanent gases by the suggestive experiments made by Pictet and Cailletet. The static liquefaction of oxygen was effected by Wroblewski in 1883, and thereby the theoretical conclusions derived from van der Waals' equation were substantially confirmed. The liquefaction of oxygen and air was achieved through the use of liquid ethylene as a cooling agent, which enabled a temperature of *minus* 140 degrees to be maintained by its steady evaporation *in vacuo*. From this time liquid oxygen and air came to be regarded as the potential cooling agents for future research, commanding as they did a temperature of 200 degrees below melting ice. The theoretical side of the question received at the hands of van der Waals a second contribution, which was even more important than his original essay, and that was his novel and ingenious development of what he calls 'The Theory of Corresponding States.' He defined the corresponding states of two substances as those in which the ratios of the temperature, pressure, and volume to the critical temperature, pressure, and volume respectively were the same for the two substances, and in corresponding states he showed that the three pairs of ratios all coincided. From this a series of remarkable propositions were developed, some new, some proving previous laws that were hitherto only empiric, and some completing and correcting faulty though approximate laws. As examples, he succeeded in calculating the boiling-point of carbonic acid from observations on ether vapour, proved Kopp's law of molecular volumes, and showed that at corresponding temperatures the molecular latent heats of vaporisation are proportional to the absolute critical temperature, and that under the same conditions the coefficients of liquid expansion are inversely proportional to the absolute critical temperature, and that the coefficients of liquid compressibility are inversely proportional to the critical pressure. All these propositions and deductions are in the main correct, though further experimental investigation has shown minor discrepancies requiring explanation. Various proposals have been made to supplement van der Waals' equation so as to bring it into line with experiments, some being entirely empiric, others theoretical. Clausius, Sarrau, Wroblewski, Batteli, and others attacked the question empirically, and in the main preserved the co-volume (depending on the total volume of the molecules) unaltered while trying to modify the constant of molecular attraction. Their success depended entirely on the fact that, instead of limiting the number of constants to three, some of them have increased them to as many as ten. On the other hand, a series of very remarkable theoretical investigations has been made by van der Waals himself, by Kammerlingh Onnes, Korteweg, Jaeger, Boltzmann, Dieterici, and Rienganum, and others, all directed in the main towards an admitted variation in the value of the co-volume while preserving the molecular attraction constant. The theoretical deductions of Tait lead to the conclusion that a substance below its critical point ought to have two different equations of the van der Waals type, one referring to the liquid and the other to the gaseous phase. One important fact was soon elicited—namely, that the law of correspondence demanded only that the equation should contain not more than three constants for each body. The simplest extension is that made by Reinganum, in which he increased the pressure for a given mean kinetic energy of the particles inversely in the ratio of the diminution of free volume, due to the molecules possessing linear extension. Berthelot has shown how a 'reduced' isothermal may be got by taking two other prominent points as units of measurement instead of the critical co-ordinates. The most suggestive advance in the improvement of the van der Waals equation has been made by a lady, Mme. Christine Meyer. The idea at the base of this new development may be understood from the following general statement: van der Waals brings the van der Waals surfaces for all substances into coincidence at the point where volume, pressure, and temperature are nothing, and then stretches or compresses all the surfaces parallel to the three axes of volume, pressure, and temperature, until their critical points coincide. But on this plan the surfaces do not quite coincide, because the points where the three variables are respectively nothing are not corresponding points. Mme. Meyer's plan is to bring all the critical points first into coincidence, and then to compress or extend all the representative surfaces parallel to the three axes of volume, pressure, and temperature, until the surfaces coincide. In this way, taking twenty-nine different substances, she completely verifies from experiment van der Waals' law of correspondence. The theory of van der Waals has been one of the greatest importance in directing experimental investigation, and in attacking the difficult problems of the liquefaction of the most permanent gases. One of its greatest triumphs has been the proof that the critical constants and the boiling-point of hydrogen theoretically deduced by Wroblewski from a study of the isothermals of the gas taken far above the temperature of liquefaction are remarkably near the experimental values. We may safely infer, therefore, that if hereafter a gas be discovered in small quantity even four times more volatile than liquid hydrogen, yet by a study of its isothermals at low temperature we shall succeed in finding its most important liquid constants, although the isolation of the real liquid may for the time be impossible. It is perhaps not too much to say that as a prolific source of knowledge in the department dealing with the continuity of state in matter, it would be necessary to go back to Carnot's cycle to find a proposition of greater importance than the theory of van der Waals and his development of the law of corresponding states.

It will be apparent from what has just been said that, thanks to the labours of Andrews, van der Waals, and others, theory had again far outrun experiment. We could calculate the constants and predict some of the simple physical characteristics of liquid oxygen, hydrogen, or nitrogen with a high degree of confidence long before any one of the three had been obtained in the static liquid condition permitting of the experimental verification of the theory. This was the more tantalising, because, with whatever confidence the chemist may anticipate the substantial corroboration of his theory, he also anticipates with almost equal conviction that as he approaches more and more nearly to the zero of absolute temperature, he will encounter phenomena compelling modification, revision, and refinement of formulas which fairly covered the facts previously known. Just as nearly seventy years ago chemists were waiting for some means of getting a temperature of 100 degrees below melting ice, so ten years ago they were casting about for the means of going 100 degrees lower still. The difficulty, it need hardly be said, increases in a geometrical rather than in an arithmetical ratio. Its magnitude may be estimated from the fact that to produce liquid air in the atmosphere of an ordinary laboratory is a feat analogous to the production of liquid water starting from steam at a white heat, and working with all the implements and surroundings at the same high temperature. The problem was not so much how to produce intense cold as how to save it when produced from being immediately levelled up by the relatively superheated surroundings. Ordinary non-conducting packings were inadmissible because they are both cumbrous and opaque, while in working near the limits of our resources it is essential that the product should be visible and readily handled. It was while puzzling over this mechanical and manipulative difficulty in 1892 that it occurred to me that the principle of an arrangement used nearly twenty years before in some calorimetric experiments,[1] which was based upon the work of Dulong and Petit on radiation, might be employed with advantage as well to protect cold substances from heat as hot ones from rapid cooling. I therefore tried the effect of keeping liquefied gases in vessels having a double wall, the annular space between being very highly exhausted.[2] Experiments showed that liquid air evaporated at only one-fifth of the rate prevailing when it was placed in a similar unexhausted vessel, owing to the convective transference of heat by the gas particles being enormously reduced by the high vacuum. But, in addition, these vessels lend themselves to an arrangement by which radiant heat can also be cut off. It was found that when the inner walls were coated with a bright deposit of silver the influx of heat was diminished to one-sixth the amount entering without the metallic coating. The total effect of the high vacuum and the silvering is to reduce the ingoing heat to about 3 per cent. The efficiency of such vessels depends upon getting as high a vacuum as possible, and cold is one of the best means of effecting the desired exhaustion. All that is necessary is to fill completely the space that has to be exhausted with an easily condensable vapour, and then to freeze it out in a receptacle attached to the primary vessel that can be sealed off. The advantage of this method is that no air-pump is required, and that theoretically there is no limit to the degree of exhaustion that can be obtained. The action is rapid, provided liquid air is the cooling agent, and vapours like mercury, water, or benzol are employed. It is obvious that when we have to deal with such an exceptionally volatile liquid as hydrogen, the vapour filling may be omitted because air itself is now an easily condensable vapour. In other words, liquid hydrogen, collected in such vessels with the annular space full of air, immediately solidifies the air and thereby surrounds itself with a high vacuum. In the same way, when it shall be possible to collect a liquid boiling on the absolute scale at about 5 degrees, as compared with the 20 degrees of hydrogen, then you might have the annular space filled with the latter gas to begin with, and yet get directly a very high vacuum, owing to the solidification of the hydrogen. Many combinations of vacuum vessels can be arranged, and the lower the temperature at which we have to operate the more useful they become. Vessels of this kind are now in general use, and in them liquid air has crossed the American continent. Of the various forms, that variety is of special importance which has a spiral tube joining the bottom part of the walls, so that any liquid gas may be drawn off from the interior of such a vessel. In the working of regenerative coils such a device becomes all-important, and such special vessels cannot be dispensed with for the liquefaction of hydrogen.

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[1] 'On the Physical Constants of Hydrogenium,' *Trans. Roy. Soc.*, ed. 1873.

[2] It now appears that similar vessels were employed by Professor Violle in a research entitled 'Sur un Calorimètre par Refroidissement,' *Comptes Rendus*, 1882.

In the early experiments of Pictet and Cailletet, cooling was produced by the sudden expansion of the highly compressed gas preferably at a low temperature, the former using a jet that lasted for some time, the latter an instantaneous adiabatic expansion in a strong glass tube. Neither process was practicable as a mode of producing liquid gases, but both gave valuable indications of partial change into the liquid state by the production of a temporary mist. Linde, however, saw that the continuous use of a jet of highly compressed gas, combined with regenerative cooling, must lead to liquefaction on account of what is called the Kelvin-Joule effect; and he succeeded in making a machine, based on this principle, capable of producing liquid air for industrial purposes. These experimenters had proved that, owing to molecular attraction, compressed gases passing through a porous plug or small aperture were lowered in temperature by an amount depending on the difference of pressure and inversely as the square of the absolute temperature. This means that for a steady difference of pressure the cooling is greater the lower the temperature. The only gas that did not show cooling under such conditions was hydrogen. Instead of being cooled it became actually hotter. The reason for this apparent anomaly in the Kelvin-Joule effect is that every gas has a thermometric point of inversion above which it is heated and below which it is cooled. This inversion point, according to van der Waals, is six and three-quarter times the critical point. The efficiency of the Linde process depends on working with highly compressed gas well below the inversion temperature, and in this respect this point may be said to take the place of the critical one, when in the ordinary way direct liquefaction is being effected by the use of specific liquid cooling agents. The success of both processes depends upon working within a certain temperature range, only the Linde method gives us a much wider range of temperature within which liquefaction can be effected. This is not the case if, instead of depending on getting cooling by the internal work done by the attraction of the gas molecules, we force the compressed gas to do external work as in the well-known air machines of Kirk and Coleman. Both these inventors have pointed out that there is no limit of temperature, short of liquefaction of the gas in use in the circuit, that such machines are not capable of giving. While it is theoretically clear that such machines ought to be capable of maintaining the lowest temperatures, and that with the least expenditure of power, it is a very different matter to overcome the practical difficulties of working such machines under the conditions. Coleman kept a machine delivering air at *minus* 83 degrees for hours, but he did not carry his experiments any further. Recently Monsieur Claude, of Paris, has, however, succeeded in working a machine of this type so efficiently that he has managed to produce one litre of liquid air per horse power expended per hour in the running of the engine. This output is twice as good as that given by the Linde machine, and there is no reason to doubt that the yield will be still further improved. It is clear, therefore, that in the immediate future the production of liquid air and hydrogen will be effected most economically by the use of machines producing cold by the expenditure of mechanical work.

Liquid Hydrogen and Helium.

To the physicist the copious production of liquid air by the methods described was of peculiar interest and value as affording the means of attacking the far more difficult problem of the liquefaction of hydrogen, and even as encouraging the hope that liquid hydrogen might in time be employed for the liquefaction of yet more volatile elements, apart from the importance which its liquefaction must hold in the process of the steady advance towards the absolute zero. Hydrogen is an element of especial interest, because the study of its properties and chemical relations led great chemists like Faraday, Dumas, Daniell, Graham, and Andrews to entertain the view that if it could ever be brought into the state of liquid or solid it would reveal metallic characters. Looking to the special chemical relations of the combined hydrogen in water, alkaline oxides, acids, and salts, together with the behaviour of these substances on electrolysis, we are forced to conclude that hydrogen behaves as the analogue of a metal. After the beautiful discovery of Graham that palladium can absorb some hundreds of times its own volume of hydrogen, and still retain its lustre and general metallic character, the impression that hydrogen was probably a member of the metallic group became very general. The only chemist who adopted another view was my distinguished predecessor, Professor Odling. In his 'Manual of Chemistry,' published in 1861, he pointed out that hydrogen has chlorous as well as basic relations, and that they are as decided, important, and frequent as its other relations. From such considerations he arrived at the conclusion that hydrogen is essentially a neutral or intermediate body, and therefore we should not expect to find liquid or solid hydrogen possess the appearance of a metal. This extraordinary prevision, so characteristic of Odling, was proved to be correct some thirty-seven years after it was made. Another curious anticipation was made by Dumas in a letter addressed to Pictet, in which he says that the metal most analogous to hydrogen is magnesium, and that probably both elements have the same atomic volume, so that the density of hydrogen, for this reason, would be about the value elicited by subsequent experiments. Later on, in 1872, when Newlands began to arrange the elements in periodic groups, he regarded hydrogen as the lowest member of the chlorine family; but Mendeleef in his later classification placed hydrogen in the group of the alkaline metals; on the other hand, Dr. Johnstone Stoney classes hydrogen with the alkaline earth metals and magnesium. From this speculative divergency it is clear no definite conclusion could be reached regarding the physical properties of liquid or solid hydrogen, and the only way to arrive at the truth was to prosecute low-temperature research until success attended the efforts to produce its liquefaction. This result I definitively obtained in 1898. The case of liquid hydrogen is, in fact, an excellent illustration of the truth already referred to, that no theoretical forecast, however apparently justified by analogy, can be finally accepted as true until confirmed by actual experiment. Liquid hydrogen is a colourless transparent body of extraordinary intrinsic interest. It has a clearly defined surface, is easily seen, drops well, in spite of the fact that its surface tension is only the thirty-fifth part of that of water, or about one-fifth that of liquid air, and can be poured easily from vessel to vessel. The liquid does not conduct electricity, and, if anything, is slightly diamagnetic. Compared with an equal volume of liquid air, it requires only one-fifth the quantity of heat for vaporisation; on the other hand, its specific heat is six times that of liquid air or three times that of water. The coefficient of expansion of the fluid is remarkable, being about ten times that of the gas; it is by far the lightest liquid known to exist, its density being only one-fourteenth that of water; the lightest liquid previously known was liquid marsh gas, which is six times heavier. The only solid which has so small density as to float upon its surface is a piece of pith wood. It is by far the coldest liquid known. At ordinary atmospheric pressure it boils at *minus* 252·5 degrees or 20·5 degrees absolute. The critical point of the liquid is from 30 to 32 degrees absolute, and the critical pressure not more, but probably less, than 15 atmospheres. The vapour of the hydrogen arising from the liquid has nearly the density of air—that is, it is fourteen times that of the gas at the ordinary temperature. Reduction of the pressure by an air-pump brings down the temperature to *minus* 258 degrees, when the liquid becomes a solid resembling frozen foam, and this by further exhaustion is cooled to *minus* 259·5 degrees, or 13½ degrees absolute, which is the lowest steady temperature that has been reached. The solid may also be got in the form of a clear transparent ice, melting at about 15 degrees absolute, under a pressure of 55 mm., possessing the unique density of one-tenth that of water. Such cold involves the solidification of every gaseous substance but one that is at present definitely known to the chemist, and so liquid hydrogen introduces the investigator to a world of solid bodies. The contrast between this refrigerating substance and liquid air is most remarkable.

On the removal of the loose plug of cotton-wool used to cover the mouth of the vacuum vessel in which it is stored, the action is followed by a miniature snowstorm of solid air, formed by the freezing of the atmosphere at the point where it comes into contact with the cold vapour rising from the liquid. This solid air falls into the vessel and accumulates as a white snow at the bottom of the liquid hydrogen. When the outside of an ordinary test-tube is cooled by immersion in the liquid, it is soon observed to fill up with solid air, and if the tube be now lifted out a double effect is visible, for liquid air is produced both in the inside and on the outside of the tube—in the one case by the melting of the solid, and in the other by condensation from the atmosphere. A tuft of cotton-wool soaked in the liquid and then held near the pole of a strong magnet is attracted, and it might be inferred therefrom that liquid hydrogen is a magnetic body. This, however, is not the case: the attraction is due neither to the cotton-wool nor to the hydrogen—which indeed evaporates almost as soon as the tuft is taken out of the liquid—but to the oxygen of the air, which is well known to be a magnetic body, frozen in the wool by the extreme cold.

The strong condensing powers of liquid hydrogen afford a simple means of producing vacua of very high tenuity. When one end of a sealed tube containing ordinary air is placed for a short time in the liquid, the contained air accumulates as a solid at the bottom, while the higher part is almost entirely deprived of particles of gas. So perfect is the vacuum thus formed, that the electric discharge can be made to pass only with the greatest difficulty. Another important application of liquid air, liquid hydrogen, &c., is as analytic agents. Thus, if a gaseous mixture be cooled by means of liquid oxygen, only those constituents will be left in the gaseous state which are less condensable than oxygen. Similarly, if this gaseous residue be in its turn cooled in liquid hydrogen a still further separation will be effected, everything that is less volatile than hydrogen being condensed to a liquid or solid. By proceeding in this fashion it has been found possible to isolate helium from a mixture in which it is present to the extent of only one part in one thousand. By the evaporation of solid hydrogen under the air-pump we can reach within 13 or 14 degrees of the zero, but there or thereabouts our progress is barred. This gap of 13 degrees might seem at first sight insignificant in comparison with the hundreds that have already been conquered. But to win one degree low down the scale is quite a different matter from doing so at higher temperatures; in fact, to annihilate these few remaining degrees would be a far greater achievement than any so far accomplished in low-temperature research. For the difficulty is twofold, having to do partly with process and partly with material. The application of the methods used in the liquefaction of gases becomes continually harder and more troublesome as the working temperature is reduced; thus, to pass from liquid air to liquid hydrogen—a difference of 60 degrees—is, from a thermodynamic point of view, as difficult as to bridge the gap of 150 degrees that separates liquid chlorine and liquid air. By the use of a new liquid gas exceeding hydrogen in volatility to the same extent as hydrogen does nitrogen, the investigator might get to within five degrees of the zero; but even a second hypothetical substance, again exceeding the first one in volatility to an equal extent, would not suffice to bring him quite to the point of his ambition. That the zero will ever be reached by man is extremely improbable. A thermometer introduced into regions outside the uttermost confines of the earth's atmosphere might approach the absolute zero, provided that its parts were highly transparent to all kinds of radiation, otherwise it would be affected by the radiation of the sun, and would therefore become heated. But supposing all difficulties to be overcome, and the experimenter to be able to reach within a few degrees of the zero, it is by no means certain that he would find the near approach of the death of matter sometimes pictured. Any forecast of the phenomena that would be seen must be based on the assumption that there is continuity between the processes studied at attainable temperatures and those which take place at still lower ones. Is such an assumption justified? It is true that many changes in the properties of substances have been found to vary steadily with the degree of cold to which they are exposed. But it would be rash to take for granted that the changes which have been traced in explored regions continue to the same extent and in the same direction in those which are as yet unexplored. Of such a breakdown low-temperature research has already yielded a direct proof at least in one case. A series of experiments with pure metals showed that their electrical resistance gradually decreases as they are cooled to lower and lower temperatures, in such ratio that it appeared probable that at the zero of absolute temperature they would have no resistance at all and would become perfect conductors of electricity. This was the inference that seemed justifiable by observations taken at depths of cold which can be obtained by means of liquid air and less powerful refrigerants. But with the advent of the more powerful refrigerant liquid hydrogen it became necessary to revise that conclusion. A discrepancy was first observed when a platinum resistance thermometer was used to ascertain the temperature of that liquid boiling under atmospheric and reduced pressure. All known liquids, when forced to evaporate quickly by being placed in the exhausted receiver of an air-pump, undergo a reduction in temperature, but when hydrogen was treated in this way it appeared to be an exception. The resistance thermometer showed no such reduction as was expected, and it became a question whether it was the hydrogen or the thermometer that was behaving abnormally. Ultimately, by the adoption of other thermometrical appliances, the temperature of the hydrogen was proved to be lowered by exhaustion as theory indicated. Hence it was the platinum thermometer which had broken down; in other words, the electrical resistance of the metal employed in its construction was not, at temperatures about *minus* 250° C., decreased by cold in the same proportion as at temperatures about *minus* 200 degrees. This being the case, there is no longer any reason to suppose that at the absolute zero platinum would become a perfect conductor of electricity; and in view of the similarity between the behaviour of platinum and that of other pure metals in respect of temperature and conductivity, the presumption is that the same is true of them also. At any rate, the knowledge that in the case of at least one property of matter we have succeeded in attaining a depth of cold sufficient to bring about unexpected change in the law expressing the variation of that property with temperature, is sufficient to show the necessity for extreme caution in extending our inferences regarding the properties of matter near the zero of temperature. Lord Kelvin evidently anticipates the possibility of more remarkable electrical properties being met with in the metals near the zero. A theoretical investigation on the relation of 'electrions' and atoms has led him to suggest a hypothetical metal having the following remarkable properties: below 1 degree absolute it is a perfect insulator of electricity, at 2 degrees it shows noticeable conductivity, and at 6 degrees it possesses high conductivity. It may safely be predicted that liquid hydrogen will be the means by which many obscure problems of physics and chemistry will ultimately be solved, so that the liquefaction of the last of the old permanent gases is as pregnant now with future consequences of great scientific moment as was the liquefaction of chlorine in the early years of the last century.

The next step towards the absolute zero is to find another gas more volatile than hydrogen, and that we possess in the gas occurring in clevite, identified by Ramsay as helium, a gas which is widely distributed, like hydrogen, in the sun, stars, and nebulæ. A specimen of this gas was subjected by Olszewski to liquid air temperatures, combined with compression and subsequent expansion, following the Cailletet method, and resulted in his being unable to discover any appearance of liquefaction, even in the form of mist. His experiments led him to infer that the boiling-point of the substance is probably below 9 degrees absolute. After Lord Rayleigh had found a new source of helium in the gases which are derived from the Bath springs, and liquid hydrogen became available as a cooling agent, a specimen of helium cooled in liquid hydrogen showed the formation of fluid, but this turned out to be owing to the presence of an unknown admixture of other gases. As a matter of fact, a year before the date of this experiment I had recorded indications of the presence of unknown gases in the spectrum of helium derived from this source. When subsequently such condensable constituents were removed, the purified helium showed no signs of liquefaction, even when compressed to 80 atmospheres, while the tube containing it was surrounded with solid hydrogen. Further, on suddenly expanding, no instantaneous mist appeared. Thus helium was definitely proved to be a much more volatile substance than hydrogen in either the liquid or solid condition. The inference to be drawn from the adiabatic expansion effected under the circumstances is that helium must have touched a temperature of from 9 to 10 degrees for a short time without showing any signs of liquefaction, and consequently that the critical point must be still lower. This would force us to anticipate that the boiling-point of the liquid will be about 5 degrees absolute, or liquid helium will be four times more volatile than liquid hydrogen, just as liquid hydrogen is four times more volatile than liquid air. Although the liquefaction of the gas is a problem for the future, this does not prevent us from anticipating some of the properties of the fluid body. It would be twice as dense as liquid hydrogen if the ratio of the critical constants has the same value as in the case of hydrogen—that is to say, the critical pressure will not exceed 4 or 5 atmospheres. The liquid would on this assumption possess a very feeble surface-tension, and its compressibility and expansibility would be about four times that of liquid hydrogen, while the heat required to vaporise the molecule would be about one-fourth that of liquid hydrogen. If the critical pressure should turn out to be as high as that of nitrogen or oxygen, then the fluid density would exceed that of water and the surface-tension be increased, while the compressibility would be diminished. Heating the liquid 1 degree above its boiling-point would raise the pressure by $1\frac{3}{4}$ atmosphere, which is more than four times the increment for liquid hydrogen. The liquid would be only seventeen times denser than its vapour, whereas liquid hydrogen is sixty-five times denser than the gas it gives off. Only some 3 or 4 degrees would separate the critical temperature from the boiling-point and the melting-point, whereas in liquid hydrogen the separation is respectively 10 and 15 degrees. As the liquid refractivities for oxygen, nitrogen, and hydrogen are closely proportional to the gaseous values, and as Lord Rayleigh has shown that helium has only one-fourth the refractivity of hydrogen, although it is twice as dense, we may infer that the refractivity of liquid helium would also be about one-fourth that of liquid hydrogen, unless the critical pressure is high, which would necessitate an increase in the value. Now hydrogen has the smallest refractivity of any known liquid, and yet liquid helium will have only about one-fourth of this value—comparable, in fact, with liquid hydrogen just below its critical point. This means that the liquid will be quite exceptional in its optical properties, and very difficult to see. This may be the explanation of why no mist has been seen on its adiabatic expansion from the lowest temperatures. Taking all these remarkable properties of the liquid into consideration, one is afraid to predict that we are at present able to cope with the difficulties involved in its production and collection. Provided the critical point is, however, not below 8 degrees absolute, then from the knowledge of the conditions that are successful in producing a change of state in hydrogen through the use of liquid air, we may safely predict that helium can be liquefied by following similar methods. If, however, the critical point is as low as 6 degrees absolute, then it would be almost hopeless to anticipate success by adopting the process that works so well with hydrogen. The present anticipation is that the gas will succumb after being subjected to this process, only, instead of liquid air under exhaustion being used as the primary cooling agent, liquid hydrogen evaporating under similar circumstances must be employed. In this case the resulting liquid would require to be collected in a vacuum vessel, the outer walls of which are immersed in liquid hydrogen. The practical difficulties and the cost of the operation will be very great; but on the other hand, the descent to a temperature within 5 degrees of the zero would open out new vistas of scientific inquiry, which would add immensely to our knowledge of the properties of matter. To command in our laboratories a temperature which would be equivalent to that which a comet might reach at an infinite distance from the sun would indeed be a great triumph for science. If the present Royal Institution attack on helium should fail, then we must ultimately succeed by adopting a process based on the mechanical production of cold through the performance of external work. When a turbine can be worked by compressed helium, the whole of the mechanism and circuits being kept surrounded with liquid hydrogen, then we need hardly doubt that the liquefaction will be effected. In all probability gases other than helium will be discovered of greater volatility than hydrogen. It was at the British Association Meeting in 1896 that I made the first suggestion of the probable existence of an unknown element which would be found to fill up the gap between argon and helium, and this anticipation was soon taken up by others and ultimately confirmed. Later, in the Bakerian Lecture for 1901, I was led to infer that another member of the helium group might exist having the atomic weight about 2, and this would give us a gas still more volatile, with which the absolute zero might be still more nearly approached. It is to be hoped that some such element or elements may yet be isolated and identified as coronium or nebulium. If amongst the unknown gases possessing a very low critical point some have a high critical pressure, instead of a low one, which ordinary experience would lead us to anticipate, then such difficultly liquefiable gases would produce fluids having different physical properties from any of those with which we are acquainted. Again, gases may exist having smaller atomic weights and densities than hydrogen, yet all such gases must, according to our present views of the gaseous state, be capable of liquefaction before the zero of temperature is reached. The chemists of the future will find ample scope for investigation within the apparently limited range of temperature which separates solid hydrogen from the zero. Indeed, great as is the sentimental interest attached to the liquefaction of these refractory gases, the importance of the achievement lies rather in the fact that it opens out new fields of research and enormously widens the horizon of physical science, enabling the natural philosopher to study the properties and behaviour of matter under entirely novel conditions. This department of inquiry is as yet only in its infancy, but speedy and extensive developments may be looked for, since within recent years several special cryogenic laboratories have been established for the prosecution of such researches, and a liquid-air plant is becoming a common adjunct to the equipment of the ordinary laboratory.

The Upper Air and Auroras.

The present liquid ocean, neglecting everything for the moment but the water, was at a previous period of the earth's history part of the atmosphere, and its condensation has been brought about by the gradual cooling of the earth's surface. This resulting ocean is subjected to the pressure of the remaining uncondensed gases, and as these are slightly soluble they dissolve to some extent in the fluid. The gases in solution can be taken out by distillation or by exhausting the water, and if we compare their volume with the volume of the water as steam, we should find about 1 volume of air in 60,000 volumes of steam. This would then be about the rough proportion of the relatively permanent gas to condensable gas which existed in the case of the vaporised ocean. Now let us assume the surface of the earth gradually cooled to some 200 degrees below the freezing-point ; then, after all the present ocean was frozen, and the climate became three times more intense than any arctic frost, a new ocean of liquid air would appear, covering the entire surface of the frozen globe about 35 feet deep. We may now apply the same reasoning to the liquid air ocean that we formerly did to the water one, and this would lead us to anticipate that it might contain in solution some gases that may be far less condensable than the chief constituents of the fluid. In order to separate them we must imitate the method of taking the gases out of water. Assume a sample of liquid air cooled to the low temperature that can be reached by its own evaporation, connected by a pipe to a condenser cooled in liquid hydrogen ; then any volatile gases present in solution will distil over with the first portions of the air, and can be pumped off, being uncondensable at the temperature of the condenser. In this way, a gas mixture, containing, of the known gases, free hydrogen, helium, and neon, has been separated from liquid air. It is interesting to note in passing that the relative volatilities of water and oxygen are in the same ratio as those of liquid air and hydrogen, so that the analogy between the ocean of water and that of liquid air has another suggestive parallel. The total uncondensable gas separated in this way amounts to about one fifty-thousandth of the volume of the air, which is about the same proportion as the air dissolved in water. That free hydrogen exists in air in small amount is conclusively proved, but the actual proportion found by the process is very much smaller than Gautier has estimated by the combustion method. The recent experiments of Lord Rayleigh show that Gautier, who estimated the hydrogen present as one five-thousandth, has in some way produced more hydrogen than he can manage to extract from pure air by a repetition of the same process. The spectroscopic examination of these gases throws new light upon the question of the aurora and the nature of the upper air. On passing electric discharges through the tubes containing the most volatile of the atmospheric gases, they glow with a bright orange light, which is especially marked at the negative pole. The spectroscope shows that this light consists, in the visible part of the spectrum, chiefly of a succession of strong rays in the red, orange, and yellow, attributed to hydrogen, helium, and neon. Besides these, a vast number of rays, generally less brilliant, are distributed through the whole length of the visible spectrum. The greater part of these rays are of, as yet, unknown origin. The violet and ultra-violet part of the spectrum rivals in strength that of the red and yellow rays. As these gases probably include some of the gases that pervade interplanetary space, search was made for the prominent nebular, coronal, and auroral lines. No definite lines agreeing with the nebular spectrum could be found, but many lines occurred closely coincident with the coronal and auroral spectrum. But before discussing the spectroscopic problem it will be necessary to consider the nature and condition of the upper air.

According to the old law of Dalton, supported by the modern dynamical theory of gases, each constituent of the atmosphere while acted upon by the force of gravity forms a separate atmosphere, completely independent, except as to temperature, of the others, and the relations between the common temperature and the pressure and altitude for each specific atmosphere can be definitely expressed. If we assume the altitude and temperature known, then the pressure can be ascertained for the same height in the case of each of the gaseous constituents, and in this way the percentage composition of the atmosphere at that place may be deduced. Suppose we start with a surface atmosphere having the composition of our air, only containing two ten-thousandths of hydrogen, then at thirty-seven miles, if a sample could be procured for analysis, we believe that it would be found to contain 12 per cent. of hydrogen and only 10 per cent. of oxygen. The carbonic acid practically disappears; and by the time we reach forty-seven miles, where the temperature is *minus* 132 degrees, assuming a gradient of 3·2 degrees per mile, the nitrogen and oxygen have so thinned out that the only constituent of the upper air which is left is hydrogen. If the gradient of temperature were doubled, the elimination of the nitrogen and oxygen would take place by the time thirty-seven miles was reached, with a temperature of *minus* 220 degrees. The permanence of the composition of the air at the highest altitudes, as deduced from the basis of the dynamical theory of gases, has been discussed by Stoney, Bryan, and others. It would appear that there is a consensus of opinion that the rate at which gases like hydrogen and helium could escape from the earth's atmosphere would be excessively slow. Considering that to compensate any such loss the same gases are being supplied by actions taking place in the crust of the earth, we may safely regard them as necessarily permanent constituents of the upper air. The temperature at the elevations we have been discussing would not be sufficient to cause any liquefaction of the nitrogen and oxygen, the pressure being so low. If we assume the mean temperature as about the boiling-point of oxygen at atmospheric pressure, then a considerable amount of the carbonic acid must solidify as a mist, if the air from a lower level be cooled to this temperature; and the same result might take place with other gases of relatively small volatility which occur in air. This would explain the clouds that have been seen at an elevation of fifty miles, without assuming the possibility of water vapour being carried up so high. The temperature of the upper air must be above that on the vapour pressure curve corresponding to the barometric pressure at the locality, otherwise liquid condensation must take place. In other words, the temperature must be above the dew-point of air at that place. At higher elevations, on any reasonable assumption of temperature distribution, we inevitably reach a temperature where the air would condense, just as Fourier and Poisson supposed it would, unless the temperature is arrested in some way from approaching the zero. Both ultra-violet absorption and the prevalence of electric storms may have something to do with the maintenance of a higher mean temperature. The whole mass of the air above forty miles is not more than one seven-hundredth part of the total mass of the atmosphere, so that any rain or snow of liquid or solid air, if it did occur, would necessarily be of a very tenuous description. In any case, the dense gases tend to accumulate in the lower strata, and the lighter ones to predominate at the higher altitudes, always assuming that a steady state of equilibrium has been reached. It must be observed, however, that a sample of air taken at an elevation of nine miles has shown no difference in composition from that at the ground, whereas, according to our hypothesis, the oxygen ought to have been diminished to 17 per cent., and the carbonic acid should also have become much less. This can only be explained by assuming that a large intermixture of different layers of the atmosphere is still taking place at this elevation. This is confirmed by a study of the motions of clouds about six miles high, which reveals an average velocity of the air currents of some seventy miles an hour; such violent winds must be the means of causing the intermingling of different atmospheric strata. Some clouds, however, during hot and thundery weather, have been seen to reach an elevation of seventeen miles, so that we have direct proof that on occasion the lower layers of atmosphere are carried to a great elevation. The existence of an atmosphere at more than a hundred miles above the surface of the earth is revealed to us by the appearance of meteors and fireballs, and when we can take photographs of the spectrum of such apparitions we shall learn a great deal about the composition of the upper air. In the meantime Pickering's solitary spectrum of a meteor reveals an atmosphere of hydrogen and helium, and so far this is corroborative of the doctrine we have been discussing. It has long been recognised that the aurora is the result of electric discharges within the limits of the earth's atmosphere, but it was difficult to understand why its spectrum should be so entirely different from anything which could be produced artificially by electric discharges through rarefied air at the surface of the earth. Writing in 1879, Rand Capron, after collecting all the recorded observations, was able to enumerate no more than nine auroral rays, of which but one could with any probability be identified with rays emitted by atmospheric air under an electric discharge. Vogel attributed this want of agreement between nature and experiment, in a vague way, to difference of temperature and pressure; and Zollner thought the auroral spectrum to be one of a different order, in the sense in which the line and band spectra of nitrogen are said to be of different orders. Such statements were merely confessions of ignorance. But since that time observations of the spectra of auroras have been greatly multiplied, chiefly through the Swedish and Danish Polar Expeditions, and the length of spectrum recorded on the ultra-violet side has been greatly extended by the use of photography, so that, in a recent discussion of the results, M. Henri Stassano is able to enumerate upwards of one hundred auroral rays, of which the wave-length is more or less approximately known, some of them far in the ultra-violet. Of this large number of rays he is able to identify, within the probable limits of errors of observation, about two-thirds as rays, which Professor Liveing and myself have observed to be emitted by the most volatile gases of atmospheric air unliquefiable at the temperature of liquid hydrogen. Most of the remainder he ascribes to argon, and some he might, with more probability, have identified with krypton or xenon rays, if he had been aware of the publication of wave-lengths of the spectra of those gases, and the identification of one of the highest rays of krypton with that most characteristic of auroras. The rosy tint often seen in auroras, particularly in the streamers, appears to be due mainly to neon, of which the spectrum is remarkably rich in red and orange rays One or two neon rays are amongst those most frequently observed, while the red ray of hydrogen and one red ray of krypton have been noticed only once. The predominance of neon is not surprising, seeing that from its relatively greater proportion in air and its low density it must tend to concentrate at higher elevations. So large a number of probable identifications warrants the belief that we may yet be able to reproduce in our laboratories the auroral spectrum in its entirety. It is true that we have still to account for the appearance of some, and the absence of other, rays of the newly discovered gases, which in the way in which we stimulate them appear to be equally brilliant, and for the absence, with one doubtful exception, of all the rays of nitrogen. If we cannot give the reason of this, it is because we do not know the mechanism of luminescence—nor even whether the particles which carry the electricity are themselves luminous, or whether they only produce stresses causing other particles which encounter them to vibrate; yet we are certain that an electric discharge in a highly rarefied mixture of gases lights one element and not another, in a way which, to our ignorance, seems capricious. The Swedish North Polar Expedition concluded from a great number of trigonometrical measurements that the average above the ground of the base of the aurora was fifty kilometres (thirty-four miles) at Cape Thorsden, Spitzbergen ; at this height the pressure of the nitrogen of the atmosphere would be only about one-tenth of a millimetre, and Moissan and Deslandres have found that in atmospheric air at pressures less than one millimetre the rays of nitrogen and oxygen fade and are replaced by those of argon and by five new rays which Stassano identifies with rays of the more volatile gases measured by us. Also Collie and Ramsay's observations on the distance to which electrical discharges of equal potential traverse different gases explosively throw much light on the question ; for they find that, while for helium and neon this distance is from 250 to 300 mm., for argon it is 45½ mm., for hydrogen it is 39 mm., and for air and oxygen still less. This indicates that a good deal depends on the very constitution of the gases themselves, and certainly helps us to understand why neon and argon, which exist in the atmosphere in larger proportions than helium, krypton, or xenon, should make their appearance in the spectrum of auroras almost to the exclusion of nitrogen and oxygen. How much depends not only on the constitution and it may be temperature of the gases, but also on the character of the electric discharge, is evident from the difference between the spectra at the cathode and anode in different gases, notably in nitrogen and argon, and not less remarkably in the more volatile compounds of the atmosphere. Paulsen thinks the auroral spectrum wholly due to cathodic rays. Without stopping to discuss that question, it is certain that changes in the character of the electric discharge produce definite changes in the spectra excited by them. It has long been known that in many spectra the rays which are inconspicuous with an uncondensed electric discharge become very pronounced when a Leyden jar is in the circuit. This used to be ascribed to a higher temperature in this condensed spark, though measurements of that temperature have not borne out the explanation. Schuster and Hemsalech have shown that these changes of spectra are in part due to the oscillatory character of the condenser discharge which may be enhanced by self-induction, and the corresponding change of spectrum thereby made more pronounced. Lightning we should expect to resemble condensed discharge much more than aurora, but this is not borne out by the spectrum. Pickering's recent analysis of the spectrum of a flash obtained by photography shows, out of nineteen lines measured by him, only two which can be assigned with probability to nitrogen and oxygen, while three hydrogen rays most likely due to water are very conspicuous, and eleven may be reasonably ascribed to argon, krypton, and xenon, one to more volatile gas of the neon class, and the brightest ray of all is but a very little less refrangible than the characteristic auroral ray, and coincides with a strong ray of calcium, but also lies between, and close to, an argon and a neon ray, neither of them weak rays. There may be some doubt about the identification of the spectral rays of auroras because of the wide limits of the probable errors in measuring wave-lengths so faint as most of them are, but there is no such doubt about the wave-lengths of the rays in solar protuberances measured by Deslandres and Hale. Stassano found that these rays, forty-four in number, lying between the Fraunhofer line *F* and 3148 in the ultra-violet agree very closely with rays which Professor Liveing and myself measured in the spectra of the most volatile atmospheric gases. It will be remembered that one of the earliest suggestions as to the nature of solar prominences was that they were solar auroras. This supposition helped to explain the marvellous rapidity of their changes, and the apparent suspension of brilliant self-luminous clouds at enormous heights above the sun's surface. Now the identification of the rays of their spectra with those of the most volatile gases, which also furnish many of the auroral rays, certainly supports that suggestion. A stronger support, however, seems to be given to it by the results obtained at the total eclipse of May 1901, by the American expedition to Sumatra. In the 'Astrophysical Journal' for June last is a list of 339 lines in the spectrum of the corona photographed by Humphreys, during totality, with a very large concave grating. Of these no fewer than 209 do not differ from lines we have measured in the most volatile gases of the atmosphere, or in krypton or xenon, by more than one unit of wave-length on Armstrong's scale, a quantity within the limit of probable error. Of the remainder, a good many agree to a like degree with argon lines, a very few with oxygen lines, and still fewer with nitrogen lines; the characteristic green auroral ray, which is not in the range of Humphreys' photographs, also agrees within a small fraction of a unit of wave-length with one of the rays emitted by the most volatile atmospheric gas. Taking into account the Fraunhofer lines *H*, *K*, and *G*, usually ascribed to calcium, there remain only fifty-five lines of the 339 unaccounted for to the degree of probability indicated. Of these considerably more than half are very weak lines which have not depicted themselves on more than one of the six films exposed, and extend but a very short distance into the sun's atmosphere. There are, however, seven which are stronger lines, and reach to a considerable height above the sun's rim, and all have depicted themselves on at least four of the six films. If there be no considerable error in the wave-lengths assigned (and such is not likely to be the case), these lines may perhaps be due to some volatile element which may yet be discovered in our atmosphere. However that may be, the very great number of close coincidences between the auroral rays and those which are emitted under electric excitement by gases of our atmosphere almost constrains us to believe, what is indeed most probable on other grounds, that the sun's coronal atmosphere is composed of the same substances as the earth's, and that it is rendered luminous in the same way—namely, by electric discharges. This conclusion has plainly an important bearing on the explanation which should be given of the outburst of new stars and of the extraordinary and rapid changes in their spectra. Moreover, leaving on one side the question whether gases ever become luminous by the direct action of heat, apart from such transfers of energy as occur in chemical change and electric disturbance, it demands a revision of the theories which attribute more permanent differences between the spectra of different stars to differences of temperature, and a fuller consideration of the question whether they cannot with better reason be explained by differences in the electric conditions which prevail in the stellar atmosphere.

If we turn to the question what is the cause of the electric discharges which are generally believed to occasion auroras, but of which little more has hitherto been known than that they are connected with sun-spots and solar eruptions, recent studies of electric discharges in high vacua, with which the names of Crookes, Röntgen, Lenard, and J. J. Thomson will always be associated, have opened the way for Arrhenius to suggest a definite and rational answer. He points out that the frequent disturbances which we know to occur in the sun must cause electric discharges in the sun's atmosphere far exceeding any that occur in that of the earth. These will be attended with an ionisation of the gases, and the negative ions will stream away through the outer atmosphere of the sun into the interplanetary space, becoming, as Wilson has shown, nuclei of aggregation of condensable vapours and cosmic dust. The liquid and solid particles thus formed will be of various sizes; the larger will gravitate back to the sun, while those with diameters less than one and a half thousandths of a millimetre, but nevertheless greater than a wavelength of light, will, in accordance with Clerk-Maxwell's electromagnetic theory, be driven away from the sun by the incidence of the solar rays upon them, with velocities which may become enormous, until they meet other celestial bodies, or increase their dimensions by picking up more cosmic dust or diminish them by evaporation. The earth will catch its share of such particles on the side which is turned towards the sun, and its upper atmosphere will thereby become negatively electrified until the potential of the charge reaches such a point that a discharge occurs, which will be repeated as more charged particles reach the earth. This theory not only accounts for the auroral discharges, and the coincidence of their times of greatest frequency with those of the maxima of sunspots, but also for the minor maxima and minima. The vernal and autumnal maxima occur when the line through the earth and sun has its greatest inclination to the solar equator, so that the earth is more directly exposed to the region of maximum of sunspots, while the twenty-six days period corresponds closely with the period of rotation of that part of the solar surface where faculæ are most abundant. J. J. Thomson has pointed out, as a consequence of the Richardson observations, that negative ions will be constantly streaming from the sun merely regarded as a hot body, but this is not inconsistent with the supposition that there will be an excess of this emission in eruptions, and from the regions of faculæ. Arrhenius' theory accounts also, in a way which seems the most satisfactory hitherto enunciated, for the appearances presented by comets. The solid parts of these objects absorb the sun's rays, and as they approach the sun become heated on the side turned towards him until the volatile substances frozen in or upon them are evaporated and diffused in the gaseous state in surrounding space, where they get cooled to the temperature of liquefaction and aggregated in drops about the negative ions. The larger of these drops gravitate towards the sun and form clouds of the coma about the head, while the smaller are driven by the incidence of the sun's light upon them away from the sun and form the tail. The curvature of the tail depends, as Bredichin has shown, on the rate at which the particles are driven, which in turn depends on the size and specific gravity of the particles, and these will vary with the density of the vapour from which they are formed and the frequency of the negative ions which collect them. In any case Arrhenius' theory is a most suggestive one, not only with reference to auroras and comets, and the solar corona and chromosphere, but also as to the constitution of the photosphere itself.

Various Low-Temperature Researches.

We may now summarise some of the results which have already been attained by low-temperature studies. In the first place, the great majority of chemical interactions are entirely suspended, but an element of such exceptional powers of combination as fluorine is still active at the temperature of liquid air. Whether solid fluorine and liquid hydrogen would interact no one can at present say. Bodies naturally become denser, but even a highly expansive substance like ice does not appear to reach the density of water at the lowest temperature. This is confirmatory of the view that the particles of matter under such conditions are not packed in the closest possible way. The force of cohesion is greatly increased at low temperatures, as is shown by the additional stress required to rupture metallic wires. This fact is of interest in connection with two conflicting theories of matter. Lord Kelvin's view is that the forces that hold together the particles of bodies may be accounted for without assuming any other agency than gravitation or any other law than the Newtonian. An opposite view is that the phenomena of the aggregation of molecules depend upon the molecular vibration as a physical cause. Hence, at the zero of absolute temperature, this vibrating energy being in complete abeyance, the phenomena of cohesion should cease to exist, and matter generally be reduced to an incoherent heap of cosmic dust. This second view receives no support from experiment.

The photographic action of light is diminished at the temperature of liquid air to about 20 per cent. of its ordinary efficiency, and at the still lower temperature of liquid hydrogen only about 10 per cent. of the original sensitivity remains. At the temperature of liquid air or liquid hydrogen a large range of organic bodies and many inorganic ones acquire under exposure to violet light the property of phosphorescence. Such bodies glow faintly so long as they are kept cold, but become exceedingly brilliant during the period when the temperature is rising. Even solid air is a phosphorescent body. All the alkaline earth sulphides which phosphoresce brilliantly at the ordinary temperature lose this property when cooled, to be revived on heating; but such bodies in the first instance may be stimulated through the absorption of light at the lowest temperatures. Radio-active bodies, on the other hand, like radium, which are naturally self-luminous, maintain this luminosity unimpaired at the very lowest temperatures, and are still capable of inducing phosphorescence in bodies like the platino-cyanides. Some crystals become for a time self-luminous when cooled in liquid air or hydrogen, owing to the induced electric stimulation causing discharges between the crystal molecules. This phenomenon is very pronounced with nitrate of uranium and some platino-cyanides.

In conjunction with Professor Fleming a long series of experiments was made on the electric and magnetic properties of bodies at low temperatures. The subjects that have been under investigation may be classified as follows: The Thermo-Electric Powers of Pure Metals; The Magnetic Properties of Iron and Steel; Dielectric Constants; The Magnetic and Electric Constants of Liquid Oxygen; Magnetic Susceptibility.

The investigations have shown that electric conductivity in pure metals varies almost inversely as the absolute temperature down to *minus* 200 degrees, but that this law is greatly affected by the presence of the most minute amount of impurity. Hence the results amount to a proof that electric resistance in pure metals is closely dependent upon the molecular or atomic motion which gives rise to temperature, and that the process by which the energy constituting what is called an electric current is dissipated essentially depends upon non-homogeneity of structure and upon the absolute temperature of the material. It might be inferred that at the zero of absolute temperature resistance would vanish altogether, and all pure metals become perfect conductors of electricity. This conclusion, however, has been rendered very doubtful by subsequent observations made at still lower temperatures, which appear to point to an ultimate finite resistance. Thus the temperature at which copper was assumed to have no resistance was *minus* 223 degrees, but that metal has been cooled to *minus* 253 degrees without getting rid of all resistance. The reduction in resistance of some of the metals at the boiling-point of hydrogen is very remarkable. Thus copper has only 1 per cent., gold and platinum 3 per cent., and silver 4 per cent. of the resistance they possessed at zero C., but iron still retains 12 per cent. of its initial resistance. In the case of alloys and impure metals, cold brings about a much smaller decrease in resistivity, and in the case of carbon and insulators like gutta-percha, glass, ebonite, &c., their resistivity steadily increases. The enormous increase in resistance of bismuth when transversely magnetised and cooled was also discovered in the course of these experiments. The study of dielectric constants at low temperatures has resulted in the discovery of some interesting facts. A fundamental deduction from Maxwell's theory is that the square of the refractive index of a body should be the same number as its dielectric constant. So far, however, from this being the case generally, the exceptions are far more numerous than the coincidences. It has been shown in the case of many substances, such as ice and glass, that an increase in the frequency of the alternating electromotive force results in a reduction of the dielectric constant to a value more consistent with Maxwell's law. By experiments upon many substances it is shown that even a moderate increase of frequency brings the large dielectric constant to values quite near to that required by Maxwell's law. It was thus shown that low temperature has the same effect as high frequency in annulling the abnormal dielectric values. The exact measurement of the dielectric constant of liquid oxygen as well as its magnetic permeability, combined with the optical determination of the refractive index, showed that liquid oxygen strictly obeys Maxwell's electro-optic law even at very low electric frequencies. In magnetic work the result of greatest value is the proof that magnetic susceptibility varies inversely as the absolute temperature. This shows that the magnetisation of paramagnetic bodies is an affair of orientation of molecules, and it suggests that at the absolute zero all the feebly paramagnetic bodies will be strongly magnetic. The diamagnetism of bismuth was found to be increased at low temperatures. The magnetic moment of a steel magnet is temporarily increased by cooling in liquid air, but the increase seems to have reached a limit, because on further cooling to the temperature of liquid hydrogen hardly any further change was observed. The study of the thermo-electric relations of the metals at low temperatures resulted in a great extension of the well-known Tait Thermo-Electric Diagram. Tait found that the thermo-electric power of the metals could be expressed by a linear function of the absolute temperature, but at the extreme range of temperature now under consideration this law was found not to hold generally; and further, it appeared that many abrupt electric changes take place, which originate probably from specific molecular changes occurring in the metal. The thermo-electric neutral points of certain metals, such as lead and gold, which are located at or below the boiling-point of hydrogen, have been found to be a convenient means of defining specific temperatures in this exceptional part of the thermometric scale.

The effect of cold upon the life of living organisms is a matter of great intrinsic interest, as well as of wide theoretical importance. Experiment indicates that moderately high temperatures are much more fatal, at least to the lower forms of life, than are exceedingly low ones. Professor McKendrick froze for an hour at a temperature of *minus* 182° C. samples of meat, milk, &c., in sealed tubes; when these were opened after being kept at blood heat for a few days, their contents were found to be quite putrid. More recently some more elaborate tests were carried out at the Jenner Institute of Preventive Medicine on a series of typical bacteria. These were exposed to the temperature of liquid air for twenty hours, but their vitality was not affected, their functional activities remained unimpaired, and the cultures which they yielded were normal in every respect. The same result was obtained when liquid hydrogen was substituted for air. A similar persistence of life in seeds has been demonstrated even at the lowest temperatures; they were frozen for over a hundred hours in liquid air, at the instance of Messrs. Brown and Escombe, with no other result than to affect their protoplasm with a certain inertness, from which it recovered with warmth. Subsequently commercial samples of barley, pea, vegetable-marrow, and mustard seeds were literally steeped for six hours in liquid hydrogen at the Royal Institution, yet when they were sown by Sir W. T. Thiselton Dyer at Kew in the ordinary way, the proportion in which germination occurred was no less than in the other batches of the same seeds which had suffered no abnormal treatment. Bacteria are minute vegetable cells, the standard of measurement for which is the 'mikron.' Yet it has been found possible to completely triturate these microscopic cells, when the operation is carried out at the temperature of liquid air, the cells then being frozen into hard breakable masses. The typhoid organism has been treated in this way, and the cell plasma obtained for the purpose of studying its toxic and immunising properties. It would hardly have been anticipated that liquid air should find such immediate application in biological research. A research by Professor Macfadyen, just concluded, has shown that many varieties of micro-organisms can be exposed to the temperature of liquid air for a period of six months without any appreciable loss of vitality, although at such a temperature the ordinary chemical processes of the cell must cease. At such a temperature the cells cannot be said to be either alive or dead, in the ordinary acceptation of these words. It is a new and hitherto unobtained condition of living matter—a third state. A final instance of the application of the above methods may be given. Certain species of bacteria during the course of their vital processes are capable of emitting light. If, however, the cells be broken up at the temperature of liquid air, and the crushed contents brought to the ordinary temperature, the luminosity function is found to have disappeared. This points to the luminosity not being due to the action of a ferment—a 'Luciferase'—but as being essentially bound up with the vital processes of the cells, and dependent for its production on the intact organisation of the cell. These attempts to study by frigorific methods the physiology of the cell have already yielded valuable and encouraging results, and it is to be hoped that this line of investigation will continue to be vigorously prosecuted at the Jenner Institute.

And now, to conclude an address which must have sorely taxed your patience, I may remind you that I commenced by referring to the plaint of Elizabethan science, that cold was not a natural available product. In the course of a long struggle with nature, man, by the application of intelligent and steady industry, has acquired a control over this agency which enables him to produce it at will, and with almost any degree of intensity, short of a limit defined by the very nature of things. But the success in working what appears, at first sight, to be a quarry of research that would soon suffer exhaustion, has only brought him to the threshold of new labyrinths, the entanglements of which frustrate, with a seemingly invulnerable complexity, the hopes of further progress. In a legitimate sense all genuine scientific workers feel that they are 'the inheritors of unfulfilled renown.' The battlefields of science are the centres of a perpetual warfare, in which there is no hope of final victory, although partial conquest is ever triumphantly encouraging the continuance of the disciplined and strenuous attack on the seemingly impregnable fortress of Nature. To serve in the scientific army, to have shown some initiative, and to be rewarded by the consciousness that in the eyes of his comrades he bears the accredited accolade of successful endeavour, is enough to satisfy the legitimate ambition of every earnest student of Nature. The real warranty that the march of progress in the future will be as glorious as in the past lies in the perpetual reinforcement of the scientific ranks by recruits animated by such a spirit, and proud to obtain such a reward.

REPORTS

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Experiments for improving the Construction of Practical Standards for Electrical Measurements.—Report of the Committee, consisting of Lord Rayleigh (*Chairman*), Dr. R. T. Glazebrook (*Secretary*), Lord Kelvin, Professors W. E. Ayrton, J. Perry, W. G. Adams, *and* G. Carey Foster, Sir Oliver J. Lodge, Dr. A. Muirhead, Sir W. H. Preece, Professors J. D. Everett, A. Schuster, J. A. Fleming, *and* J. J. Thomson, Dr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Dr. G. Johnstone Stoney, Professor S. P. Thompson, Mr. J. Rennie, Mr. E. H. Griffiths, Sir A. W. Rücker, Professor H. L. Callendar, Sir W. C. Roberts-Austen, *and* Mr. George Matthey.

Appendix.—*On the Definition of the Unit of Heat* 55

During the past year the apparatus belonging to the Association has been removed to and set up at the National Physical Laboratory at Bushy House. A room in the basement has been fitted for accurate resistance work. By means of a thermostat the temperature can be kept under very complete control, and the room has proved most suitable for its purpose. In it the resistance standards of the Association have been set up, and a number of comparisons have been made by Mr. F. E. Smith. Particulars as to the results of these comparisons can best be given at a later date, when the mercury standards now in course of construction have been set up.

The work of setting up the mercury standards of resistance has been further advanced. A number of tubes, both of verre dur and of Jena glass, $16'''$, have been calibrated by Mr. Smith. When the final corrections to the weights used have been obtained from the Bureau International it will be possible to complete these and to determine the values of the platinum-silver and manganin standards in terms of the mercury unit.

From the resistance-room a cellar—formerly the wine-cellar of Bushy House—opens, and in it work requiring an extreme constancy of temperature can be carried on.

In this room Mr. Smith has set up a number both of Clark and also of Weston cells, and comparisons between these have been carried on systematically.

Discrepancies of a considerable amount have been found between cells set up in the same manner, but from materials supplied by various makers, and these have been traced to the mercurous sulphate. The observers at the Reichsanstalt have come to a similar conclusion.[1] Dr. Carpenter and Mr. Smith are now engaged in experiments at the National Physical Laboratory, the results of which, it is hoped, will enable them to specify a method of preparing mercurous sulphate which will lead to consistent results for the E.M.F. of the cells.

The air condensers belonging to the Committee have been set up, and a number of determinations of their capacity have been made by Mr. Campbell. The results of these, though at present they are only to be treated as provisional, show that the condensers are in good order, and have suffered no damage by their journeys first to Liverpool and then to Richmond. The capacity of one is nearly the same as when at Cambridge; that of the other has altered very slightly. With a view of establishing a standard of capacity a number of other comparisons between the standards of the Association and those of Dr. Muirhead are in progress.

In this comparison work some difficulty has arisen from the fact that all the resistance-boxes belonging to the Association are of platinum-silver. The small temperature coefficient of manganin gives that material a very distinct advantage, and the Secretary has been endeavouring to use it whenever possible. It would be of great service for this part of the work to have a subdivided megohm-box in manganin, and the Committee trust that funds for this may be forthcoming. They hope in their next report to give a detailed account of the condenser experiments.

The construction of platinum thermometers as standards for high temperature thermometry has made some progress. The National Physical Laboratory was not opened until March, and the work of setting up the apparatus, carrying out the necessary calibrations, &c., has occupied most of the time of the assistants since then.

After some further experiments however, to test the purity of the wire it was proposed to use had been carried out, a stock of eight ounces of wire of the highest purity and of a thickness varying from six to eight mils has been bought from Messrs. Johnson & Matthey, while four ounces of the same wire, but of twenty-two mils in thickness, suitable for leads or for drawing down to special sizes, have also been secured; and six thermometers are in course of construction in the workshops of the Laboratory under Dr. Harker's supervision.

Of these six thermometers two of five ohms fundamental interval will be hermetically sealed in glass tubes, and will serve as standards for low-temperature work; a second pair, having an interval of one ohm, in tubes of hard glass—probably Jena—59‴—will serve for temperatures up to 550° C., while the third pair, also of one ohm interval, in porcelain tubes, will be employed up to 1100° or 1200° C. It is hoped by the use of quartz to extend the range of temperature considerably, and some experiments are in progress with this object.

Two electrical resistance ovens have been built by Dr. Harker for high-temperature work, and these serve their purpose admirably.

The grants voted during the past two years have been expended on the purchase of the materials for the platinum thermometers, and additional sums are necessary to complete their manufacture.

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[1] *Thätigkeit der Phys.-Tech.-Reichsanstalt*, 1901–1902.

With regard to the construction of the ampere balance the Committee are sorry that they cannot report progress; they have learnt with extreme regret of Professor Ayrton's ill-health during part of the year, but are glad to know that he believes he will be able to continue his investigations into this important question, and they have therefore reason to hope the matter will be advanced.

In this work the late Principal Viriamu Jones was closely associated with Professor Ayrton, and it is a source of great pleasure to the Committee to know that, through the generosity of the Drapers' Company, his name and connection with Electrical Measurements will be perpetuated at the National Physical Laboratory. The Company had promised to Principal Jones the funds for the construction of an improved Lorenz apparatus for the determination of the ohm, and they have intimated to the Committee of the Laboratory their intention to place 700*l.* at the Executive Committee's disposal for the construction of such an apparatus in his memory under the superintendence of Professor Ayrton and the Director of the National Physical Laboratory. The Secretary states that steps have already been taken to obtain designs for the instrument.

At the Meeting in Belfast Sir William Preece drew the attention of the Commitee to the work of the Standardisation Committee of the Engineering Societies, and expressed the hope that in his capacity as chairman of the electrical branch of that committee he might have the assistance of the Electrical Standards Committee. The Secretary was instructed to afford all the assistance in his power.

Reference was also made to the definition of the unit of heat, and the Secretary was requested, with the assistance of Mr. Griffiths, to draw up an Appendix to the Report dealing with this. The Committee expressed the strong hope that any unit of heat formally accepted by engineers should be based on the C.G.S. system of units.

In conclusion the Committee recommend that they be reappointed, with a grant of 75*l.*, to be used for the establishment of a standard of capacity and for the construction of standard platinum thermometers; that Lord Rayleigh be Chairman and Mr. R. T. Glazebrook Secretary.

APPENDIX.

On the Definition of the Unit of Heat.

The question of the definition of the unit of heat has been before the Committee on various occasions.

In 1896, at the Liverpool Meeting, after an exhaustive discussion and the consideration of letters from scientific men in all parts of the world, the following propositions were provisionally approved:—

Proposition I.—For many purposes heat is most conveniently measured in units of energy, and the theoretical C.G.S. units of heat is one erg. The name 'joule' has been given by the Electrical Standards Committee to 10^7 ergs.

For many practical purposes heat will continue to be measured in terms of the heat required to raise a measured mass of water through a definite range of temperature.

If the mass of water be one gramme, and the range of temperature 1° C. of the hydrogen thermometer from 9°·5 C. to 10°·5 C. of the scale of that thermometer, then, according to the best of the existing determinations the amount of heat required is 4·2 joules.

It will therefore be convenient to fix upon this number of joules as a secondary unit of heat.

This secondary thermal unit may be called a 'calorie.'

For the present a second proposition is—

Proposition II.—The amount of heat required to raise the temperature of one gramme of water 1° C. of the scale of the hydrogen thermometer at a mean temperature which may be taken as 10° C. of that thermometer is 4·2 joules.

If further research should show that the statement in II. is not exact, the definition could be adjusted by a small alteration in the mean temperature at which the rise of 1° takes place. The definition in I. and the number (4·2) of joules in a calorie would remain unaltered.

These propositions, it will be observed, while reaffirming the names 'joule' as the equivalent of 10^7 ergs, and calorie, the equivalent of 4·2 joules, as the amount of heat required to raise the temperature of one gramme of water one degree centigrade on the hydrogen scale, leave undetermined the mean temperature of the water so raised. Proposition II. states that this may be taken as 10° C., but it is pointed out that if the heat required to raise one gramme of water from 9°·5 to 10°·5 C. should prove not to be 4·2 joules, a readjustment in the mean temperature employed in the definition could easily be made.

Accordingly in the Report, 1897, made at Toronto the Committee wrote:—

'At the Liverpool Meeting the committee agreed that the "calorie," defined as the heat equivalent of $4{\cdot}2 \times 10^7$ ergs, should be adopted as the unit for the measurement of quantities of heat, but the question as to the exact part of the absolute thermodynamic scale of temperature at which this quantity of heat could be taken as equal to one water-gramme-degree was for the time being left open.

'This resolution has made it incumbent on the Committee to consider carefully—

'1. The relation between the results of measurements of intervals of temperature by accepted methods and the absolute scale.

'2. The specific heat of water in terms of the erg and its variation with temperature.

'With regard to the first point there appears to be no reason to doubt that the scale of a constant-volume hydrogen thermometer is very nearly identical with the absolute scale. The Committee have therefore decided to recognise the standard hydrogen thermometer of the Bureau International des Poids et Mesures as representing, nearly enough for present purposes, the absolute scale. This convention has at least the advantage of giving a definite meaning to statements of the numerical value of intervals of temperature within any range for which comparison with the hydrogen thermometer is practicable. If future investigation should show that it is inaccurate to any appreciable extent, corresponding corrections can be applied when necessary.'

As regards the second point further research has shown that an alteration in the temperature of measurement is required. The present position has been summed up by Principal Griffiths in the 'Rapports présentés au Congrès International de Physique,' Paris, 1900, tome i., and in his Lectures on the Thermal Measurement of Energy.[1] They are also summarised by Professor Everett in the latest edition of his work, 'C.G.S. Units and Constants.'

The following table, taken from Professor Everett's work, gives the results adopted by Principal Griffiths.

From this it follows that the heat required to raise a gramme of water 1° on the hydrogen scale is 4·2 joules when the size of temperature is from 7°·2 C. to 8°·2 C. Thus according to this the 10° C. of Proposition II. should be 7°·7 C., and a calorie would be the heat required to raise a gramme of water 1° of the hydrogen scale from 7°·2 to 8°·2 of that scale.

Tables of Mechanical Equivalents in Joules.

1 joule = 10^7 ergs.
Rowland, reduced by Day. Hydrogen scale.

°		°		°		°	
5	[4·205]	13	4·191	21	4·180	29	4·174
6	4·203	14	4·189	22	4·179	30	4·174
7	4·201	15	4·188	23	4·178	31	4·174
8	4·199	16	4·186	24	4·177	32	4·174
9	4·198	17	4·185	25	4·176	33	4·174
10	4·196	18	4·184	26	4·176	34	4·174
11	4·194	19	4·182	27	4·175	35	4·175
12	4·192	20	4·181	28	4·175	36	4·175

—	Day Hyd.	Barnes Air	Barnes Hyd.	Griffiths adopted
°				
0	—	—	—	[4·219]
5	[4·205]	4·210	4·213	4·206
10	4·196	4·198	4·200	4·195
15	4·188	4·189	4·191	4·187
20	4·181	4·184	4·185	4·181
25	4·176	4·180	4·180	4·176
30	4·174	4·178	4·178	4·174
35	4·175	4·177	4·177	4·173
40	—	4·177	4·177	4·173
45	—	4·178	4·178	4·173
50	—	4·180	4·178	4·174
55	—	4·182	4·181	4·176
60	—	4·184	4·183	4·178
65	—	4·187	4·185	4·181
70	—	4·190	4·188	4·184
75	—	4·192	4·191	4·187
80	—	4·195	4·195	4·190
85	—	4·198	4·198	4·193
90	—	4·201	4·201	4·197
95	—	4·204	4·205	4·201
100	—	—	—	[4·205]
Mean, giving half-weight to 0° and 100°				4·1854

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[1] Cambridge University Press, 1901.

The results of a series of observations on the heat required to raise a gramme of water from 0° C. to 100° C. were published by Reynolds and Moorby in 1897. The quantity necessary is proved to be 418·4 joules. Thus the mean heat required to raise a gramme 1° C. for temperatures between 0° and 100° is 4·184 joules. This number is not far from the 4·2 joules adopted in 1896 as the number of heat units in a calorie. Accordingly the suggestion has been made that it would be convenient to change the definition of a calorie and take it to be one-hundredth part of the heat required to raise one gramme of water from 0° C. to 100° C. In this case, according to the mean number adopted by Griffiths (see table), one calorie would be equal to 4·1854 joules, while according to Reynolds and Moorby it would be 4·184 joules, while the degree centigrade through which it would be necessary to raise one gramme of water in order to absorb an amount of heat equal to one calorie would be from 17° to 18° C.

If this view were taken, then instead of Proposition II. of 1896 we should read :—

One calorie is the amount of heat required to raise the temperature of a gramme of water from 17° C. to 18° C. on the scale of the hydrogen thermometer, and is equal to 4·184 joules.

It should be noted, however, that the Committee have not as yet taken any resolution on the point, and that formally the propositions accepted in 1896 and reprinted above are those which they have approved.

It should also be mentioned that in deference to international representations the use of the word 'therm' was withdrawn in 1896, the name being replaced by the word 'calorie.'

Comparing and Reducing Magnetic Observations.—Report of the Committee, consisting of Professor W. G. ADAMS (*Chairman*), Dr. C. CHREE (*Secretary*), Lord KELVIN, Professor G. CHRYSTAL, Professor A. SCHUSTER, Captain E. W. CREAK, the ASTRONOMER ROYAL, Mr. WILLIAM ELLIS, *and* Sir A. W. RÜCKER.

THE Committee have been in existence since 1885, and have exerted a beneficial and important influence on terrestial magnetism. Questions connected with the comparison and reduction of magnetic observations do not now, however, seem naturally to come under the cognisance of the Committee. Of late years the reports have really been papers, for which individual members have been responsible, and which have called for no corporate action. The creation of an international committee naturally affords a more direct means of communication between the observers of different countries, whilst the existence of the journal 'Terrestrial Magnetism' affords a means of reaching with greater certainty the limited class really interested in the subject. Under these circumstances it seems best that the Committee should not ask for reappointment.

Seismological Investigations.—Seventh Report of the Committee, consisting of Professor J. W. JUDD (*Chairman*), Mr. J. MILNE (*Secretary*), Lord KELVIN, Professor T. G. BONNEY, Mr. C. V. BOYS, Professor G. H. DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Professor J. A. EWING, Dr. R. T. GLAZEBROOK, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Mr. W. E. PLUMMER, Professor J. H. POYNTING, Mr. CLEMENT REID, Mr. NELSON RICHARDSON, *and* Professor H. H. TURNER. *(Drawn up by the Secretary.)*

PLATE I.

CONTENTS.

PAGE
I. *On Seismological Stations abroad and in Great Britain* 59
II. *The Instruments in use at Shide* 60
III. *The Origins of the Earthquakes recorded in* 1899, 1900, *and* 1901 . . . 61
IV. *Duration of the First Preliminary Tremors* 64
V. *Time Curves for Earthquakes recorded during the four years ending December* 31, 1900 65
VI. *The Comparison of the Records obtained from three horizontal pendulums at Shide* 68
VII. *Clinometric Experiments* 70
VIII. *Vertical Spring Seismograph Experiments* 71
IX. *On the Nature of Earthquake Movement* 71
X. *Relationship between Rockfolding, Seismic, and Volcanic Activities* . . 72
XI. *On the Comparison of Earthquake Registers from Shide, Kew, Bidston, and Edinburgh* 73
XII. *Experiments at the Ridgeway Fault. By* HORACE DARWIN . . . 75

I. *On Seismological Stations abroad and in Great Britain.*

SEISMOGRAPHS of the type recommended by the Seismological Investigation Committee of the British Association have been constructed for and in most instances are already established at the following stations :—

1.	Africa.	Cape Town.
2.	„	Cairo.
3.	Australia	Melbourne.
4.	„	Sydney.
5.	„	Perth.
6.	Azores (2 instruments).	
7.	Canada	Toronto.
8.	„	Victoria, B.C.
9.	Ceylon	Colombo.
10.	England	Shide, Isle of Wight.
11.	„	Kew.
12.	„	Bidston.
13.	Germany	Strasburg.
14.	Hawaii	Honolulu.
15.	India	Calcutta.
16.	„	Madras, Kodaikanal.
17.	„	„ Vizagapatam.
18.	„	Bombay.
19.	Java	Batavia.
20.	Japan	Tokio.
21.	Mauritius	Royal Alfred Observatory.
22.	Mexico	Mexico.
23.	New Zealand	Wellington.
24.	„	Christchurch.
25.	Portugal	Coimbra.
26.	Russia	Irkutsk.
27.	„	Tiflis.
28.	„	Taschkent.
29.	Scotland	Edinburgh.
30.	„	Paisley.
31.	S. America	Cordova (Argentina).
32.	„	Arequipa.
33.	Spain	San Fernando.
34.	Syria	Beyrut.
35.	Trinidad.	
36.	U.S. of America	Philadelphia.
37.	„	Baltimore.
38.	Antarctic Regions	ss. 'Discovery.'

The last registers issued by the British Association Committee are Circulars Nos. 4 and 5. These refer to Shide, Kew, Bidston, Edinburgh, Strasburg, Toronto, Victoria (B.C.), San Fernando (Spain), Cairo, Cape of Good Hope, Calcutta, Bombay, Kodaikanal, Batavia, Trinidad, Baltimore, Mauritius, Perth, and Irkutsk. To these is added a list of local earthquakes observed in 1901 in Japan. A register of earthquakes observed by Mr. G. Hogben at Wellington, in New Zealand, commencing October 3, 1900, will appear in the next Circular. It is expected that these will be supplemented by a corresponding register drawn up by Mr. Coleridge Farr, of Christchurch, in New Zealand. Mr. Hogben is inclined to the opinion that many of his records refer to disturbances originating in the Antarctic regions, and these he has arranged to exchange by means of the relief expedition with those which may have been obtained by the landing party from the ss. 'Discovery.'

The last instruments despatched were those sent to Mr. F. A. Chaves, Director of the meteorological station at St. Michael, in the Azores. They left the maker, R. D. Munro, Granville Place, King's Cross Road, London, on May 16 of this year.

II. *The Instruments regularly in use at Shide.*

1. A photographing recording horizontal pendulum oriented north and south. This is the type of instrument similar to those in use at the other stations. It is adjusted to have a period of seventeen seconds, and with this adjustment a 4° turn of the calibrating screw results in a deflection of the outer end of the boom of 14 mm. As in all instruments a 1° turn of the screw causes a tilt of $1''\cdot9$, the above adjustment means that a deflection of 1 mm. at the outer end of the boom is equivalent to a tilt of $0''\cdot54$. This stands on a brick pier 18 inches square and 4 feet high above its footings, which rest on a beds of concrete above the chalk formation.

When a rope is placed round this column 2 inches below its upper edge, and this is pulled, the deflection of the upper surface of the column is equivalent to $0''\cdot095$ per 1-lb. pull.

For certain experimental purposes this adjustment of 14 mm. deflection for 4° turn of the calibrating screw is the one now adopted at Kew, Bidston, and Edinburgh (see p. 75). If the instrument is regarded as a 'steady point' seismograph, and records horizontal motion, such motion is theoretically multiplied 6·7 times.

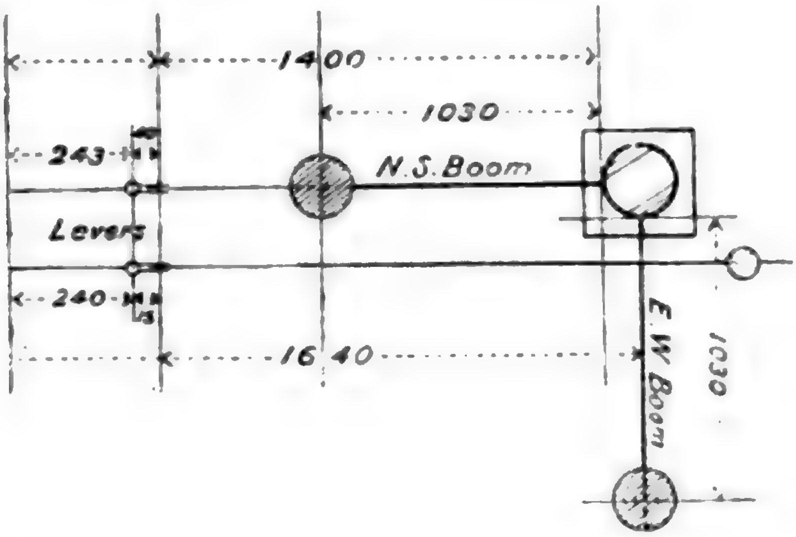
2. A pair of pendulums similar to the above oriented north-south and east-west. This instrument is referred to under the name of its donor, Mr. A. F. Yarrow. The booms of this instrument swing on the same vertical upright. The one recording north-south motion has the same dimensions as those of the type instruments. The other boom, recording east-west motion, is only 5½ inches in length; but there is cranked to it at right angles a light recording pointer, the arrangement being similar to that shown in fig. 1. By this device the records of two components of motion are obtained side by side upon the same band of paper.

This instrument is installed in a building about 50 yards distant from that in which the type instrument is placed. It stands upon a rectangular brick column, the east-west dimension of which is 18 inches, and the north-south dimension is 37 inches. This is 5 feet 3 inches in height above its footings. Its deflection constant, determined as above, is in an east-west direction, 1-lb. pull $= 0''\cdot14$. In a north-south direction, as inferred from experiments upon other similar columns, the deflection per 1-lb. pull will probably be one quarter of the above, or 0″·035.

3. A pair of horizontal pendulums writing on smoked paper. The booms of these pendulums, which are made of bicycle tubing, are each 1·030 m. in length and carry at their outer ends 80-lb. weights. The vertical support for these pendulums is a lamp-post bedded in concrete. The vertical distance between the top of the ties which carry the weights at the ends of the booms and the points where the inner ends of the booms pivot against blocks attached to the lower part of the lamp-post is 7 feet 11⅓ inches. As at present adjusted a motion of the outer end of the boom oriented north-south is by means of a light lever multiplied six times, whilst the movement of an arm cranked to the east-west boom is by a similar arrangement multiplied sixteen times.

A plan of the arrangement is shown in fig. 1. The dimensions are in millimetres.

FIG. 1. —Measurements in Millimetres.



From these dimensions it follows that if each boom were tilted equally the diagram for the north-south boom should be 3·1 times greater than that given by the east-west boom.

If the weights carried by the boom be regarded as centres of oscillation the multiplication of horizontal motion can be calculated from the dimensions given in fig. 1.

This instrument takes the place of a pair of horizontal pendulums which carried weights of 10 lb. This instrument, a spiral spring seismograph, and a large balance arranged to record tilting, which are referred to in the Report for last year, are no longer in use. The character of the records obtained from the last two of these instruments is referred to on pp. 70 and 71.

III. *The Records of the Years* 1899, 1900, *and* 1901.

In the Report of the British Association for 1900, on p. 70, a map is given showing the origins from which the earthquakes recorded in Britain during the year 1899 had radiated. These origins were determined by methods explained on pp. 79 and 80 of that report. The accompanying map, fig. 2 (Plate I.), gives a similar distribution—each earthquake being referred to by its numbers in the Shide register—for the records obtained in the years 1900 and 1901. An attempt has been made to place these earthquakes in groups, each group being enclosed by a dotted line. Altogether there are twelve such groups which on the map are indicated by the first twelve letters of the alphabet. A glance at this map shows that certain of these groups, like B and C, overlap, whilst there are many instances where origins are placed outside the boundaries of any of the groups. It is therefore likely that when the data on which these groupings are based become more complete the same will be subjected to modifications. The large numerals indicate the number of earthquakes which originated in the districts marked A, B, C, &c., in the years 1899, 1900, and 1901. The notched bands give the direction of prominent ridges on the face of the globe, whilst the dotted areas are the 'deeps' or depressions in the beds of various oceans exceeding 3,000 fathoms in depth.

That there is a relationship between the distribution of the origins of large earthquakes and the pronounced irregularities on the surface of the earth will be seen from the following notes.

A. *Alaskan Region* (number of earthquakes 25).—The average depth of the water in this bight is about 2,000 fathoms, but in its northern part depths of 2,200 fathoms have been found within sixty miles of the shore. On this shore Mount St. Elias rises to a height of 18,000 feet. An average slope from the land to the sea on a north south line can be found which exceeds 100 feet per mile. This is over a distance of 180 miles.

On the face of this and neighbouring slopes during the last three years it is probable that molar displacements of great magnitude have taken place. On September 10, 1899, in the island of Kanak, opposite Yakuta, a graveyard sank so that on the next day a boat was able to row over the place where it had been, and the tops of the submerged trees could be seen. Many of the earthquakes from this region have yielded large seismograms at the Cape of Good Hope, which is antipodean to Alaska. We have here a district partly belonging to the Alutian ridge, off the southern shores of which within eighty miles of land depths of 4,000 fathoms have been noted, where orogenic processes are now marked the extent of which will probably be gauged by future soundings.

B. *Cordillerean Region* (number of earthquakes 14).—This region forms the western side of the Mexican plateau and the Cordilleras. Just south of the 20° parallel a depth of 2,800 fathoms has been found within forty miles of the shore, whilst depths exceeding 2,000 fathoms have been found a little over 100 miles from the land, somewhat farther to the south. Although there are peaks in these regions rising to heights close upon 18,000 feet, the average height of the ranges does not greatly exceed 6,000 feet. There are, therefore, in this region slopes of 180 to 570 feet per mile, and the instability of these is testified by the frequency of their yieldings.

C. *Antillean Region* (number of earthquakes 16).—Here we have at least two ridges to consider—that of Cuba, Haiti, and Puerto Rico running east and west, and that of Grenada, St. Vincent, Martinique, Dominica, and other islands running north and south. The east-west ridge slopes steeply to the north into water which north of Puerto Rico attains a depth of 4,000 fathoms, and to the south into water 2,500 fathoms in depth. These depths are respectively found at distances of sixty and forty miles off land and indicate slopes of 400 and 375 feet per mile. With the north-south ridge the slopes to the west over a short distance like twelve miles is 1,000 feet per mile, whilst to the eastwards it is comparatively gentle. If these gradients be measured in lengths of 200 miles the slopes are about 70 feet per mile.

D. *Andean District* (number of earthquakes 12).—At many points on the west coast of South America, within fifty miles of the shore, depths of from 2,000 to 4,000 fathoms occur, which correspond to gradients of from 250 to 480 feet per mile. Within a distance of 150 miles from the shore the land rises to a height of 12,000 feet, so that the gradients from them to the bottom of the neighbouring ocean may be taken at 120 to 180 feet per mile.

E. *Japan District* (number of earthquakes 29).—To the east of Northern Japan and the Kuriles, at a distance of about 180 miles off shore, depths of 4,000 and even 4,600 fathoms are found, indicating gradients of 130 to 150 feet per mile, and from observations made in Japan it is known that many of the large earthquakes originate on the face or at the bottom of these slopes.

F. *Javan District* (number of earthquakes 41).—Off the south-west coast of Sumatra and the south coast of Java, at distances of from eighty to 100 miles, depths of from 2,000 to 3,000 fathoms occur. The straits on the opposite shores of these islands are shallow, seldom exceeding thirty fathoms. Eastwards, from Java as far as Ceram, soundings between 1,000 and 2,000 fathoms are frequent. At one point fifty miles south of the latter island there is a depth of 4,000 fathoms. From this particular 'deep' on September 29, 1899, a displacement took place the effects of which were partially visible by subsidences on the southern coast of Ceram. In this district the sub-oceanic irregularities in contour are as irregularly distributed as the islands which form their outcrops.

G. *Mauritian District* (number of earthquakes 17).—The origins for this group of earthquakes are not well defined. They are probably related to the depression lying between the ridges represented by the Laccadives and Maldives on the east, and the Seychelles and Mascarine Islands to the south-west.

H. *North-eastern Atlantic* (number of earthquakes 22).

I. *North-western Atlantic* (number of earthquakes 3).

J. *North Atlantic* (number of earthquakes 3).

The earthquakes originating in these districts have been few in number, comparatively small, and their origins are not well defined. Although a ridge is marked as extending up the Atlantic, it is comparatively small, and even in the vicinity of the Azores it is difficult to find a gradient over a distance of 180 miles which exceeds 33 feet per mile.

K. *Alpine, Balkan, Caucasian, Himalayan Districts* (number of earthquakes 14).—Strictly speaking this region, which is the only one from which earthquakes originate on a land surface, might be divided into four or more sub-regions according to the direction of the strike of the ridges which each represents.

The most pronounced foldings are in the eastern part of these districts where in distances of 100 miles gradients of 120 feet per mile can be found, and it is from these steep slopes that the larger earthquakes have originated

IV. *Duration of the First Preliminary Tremors.*

In seismograms from the Milne horizontal pendulum the first preliminary tremors, which usually appear as a thickening of the normal trace, are only seen in connection with fairly large disturbances. The reason for this is at least twofold : first, as a recorder of elastic vibrations the multiplication of the instrument is low, with the result that when these vibrations are minute they may be lost in the thickness of the trace ; and second, because as the recording surface only moves at a rate of 1 mm. per minute it is difficult to measure very small intervals of time. For 'near' earthquakes, therefore, the seismograms usually show a disturbance commencing suddenly, and the duration of the preliminary tremors connected with the same can only be inferred by the continuation of the curve of the durations of the movements as recorded at distant stations backwards towards its origin. It is satisfactory to notice that these inferred durations closely agree with actual measurements of the same made by seismographs adapted to record 'near' earthquakes.

The following four tables give the durations of preliminary tremors in minutes for earthquakes originating near Japan, Mexico, Alaska, or in the East Indies as recorded at Shide, Kew, Toronto, Victoria (B.C.), Bombay, Batavia, Mauritius, Madras, and the Cape of Good Hope.

The number following a duration and placed in parenthesis is the number of the earthquake as entered in the Shide register. For districts see map, fig. 2 (Plate I.).

Origins West of Alaska (District A).

Victoria, B.C.	Distant	20°	Durations	3 (344), 2 (345), 7 (454).
Toronto	,,	40°	,,	5 (282), 8 (309), 6 (333), 6 (337), 7 (341), 5 (442), 10 (454).
Shide, I.W.	,,	70°	,,	11 (282), 5 (333), 6 (341), 8 (344), 8 (442), 8 (454).
Kew	,,	70°	,,	8 (333), 7 (337), 9 (338), 10 (442).
San Fernando (Spain)	,,	77°	,,	9 (309), 9 (337), 9 (442).
Bombay	,,	100°	,,	10 (309), 10 (454).
Batavia	,,	108	,,	9 (454).

Origins in or near Mexico (Districts B and C).

Victoria, B.C.	Distant	30°	Durations	6 (381), 4 (445), 4 (447), 4 (472), 7 (483).
Toronto	,,	34°	,,	5 (250), 3 (294), 6 (381), 6 (407).
			,,	5 (415), 3 (422), 5 (445), 4 (447), 4 (455), 7 (472).
Shide, I.W.	,,	84°	,,	13 (157), 4 (189), 9 (215) 10 (248), 8 (294), 10 (407), 10 (455)
Kew	,,	84°	,,	9 (250), 10 (381), 11 (407), 9 (445), 10 (455).
San Fernando (Spain)	,,	86°	,,	10 (294), 10 (381), 7 445).
Cape of Good Hope	,,	138°	,,	8 (445).
Bombay	,,	148°	,,	10 (483).
Batavia	,,	150°	,,	8 (483).

Origins near Japan (District E).

Victoria, B.C.	Distant	60°	Durations	8 (364), 8 (514), 8 (516).
Bombay	,,	65°	,,	9 (364).
Shide, I.W.	,,	87°	,,	8 (317), 10 (366), 7 (405), 10 (450), 10 (514), 10 (516)
Kew	,,	87°	,,	10 (514).
Toronto	,,	90°	,,	9 (364)

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Origins in the East Indies (*District* F).

Batavia . . .	Distant 22° . .	Durations 5 (441), 10 (505).
Bombay . . .	„ 62° . .	„ 8 (347), 10 (435), 7 (505).
Mauritius . .	„ 73° . .	„ 10 (324).
Cape of Good Hope	„ 105° . .	„ 12 (377).
Victoria, B.C. . .	„ 105° . .	„ 10 (324), 9 (347), 8 (354) 9 (377).
Shide, I.W. . .	„ 121° . .	„ 7 (133), 4 (134), 10 (324), 5 (347), 10 (355), 12 (404), 13 (460).
Kew . . .	„ 121° . .	„ 14 (505).
Toronto . . .	„ 136° . .	„ 10 (324).

Average values for the above durations which represent the intervals in minutes by which the preliminary tremors have outraced the second phase of motion at distances of 20, 30, 40, 50, 60, 70, 80, 90, and 100 degrees from their origins are, 4, 4·5, 6·5, 7·2, 8, 8·5, 9, 9·5, and 9·7 minutes. The materials to continue plotting the curve represented by these figures, which is shown in fig. 3, indicate that ten minutes is approximately the limit by which the second phase of motion is outraced by the preliminary tremors, and this limit is reached at a distance of ninety to 100 degrees from an origin.

V. *Time Curves for the Earthquakes recorded during four years ending in* 1900.

In the British Association Report for 1900, p. 67, time curves for the large waves and preliminary tremors of earthquakes recorded at long distances from their origins are given. These curves are based upon records obtained from Milne horizontal pendulums prior to the year 1900. In fig. 3 similar curves, together with a curve for the second phase of earthquake motion, are given for observations made in 1900. The curve for the second phase of motion, which corresponds to a curve given by Mr. R. T. Oldham,[1] was obtained by adding the time ordinates of the lowest curve in this figure, discussed in the previous section, to those of the time curve for the preliminary tremors. It is of interest to note that this curve would closely correspond with a curve representing the mean position of the signs × which are direct measurements of the time taken by the second phase of motion to traverse varying distances, and are not included in the materials upon which the lowest curve is based.

The individual observations relating to large waves are indicated by small crosses (+), whilst those referring to the preliminary tremors are marked by small circles. It is clear that the concordance between these and their average position as represented by the curves is not so close as could be desired. They do not dispose of the indication based on prior observations that the apparent velocity of large waves is not uniform, but may be at its maximum in quadrantal regions. Also, as has been shown in the time curves published in 1900, we see that the apparent velocity of preliminary tremors may also be increased in regions 60° to 90° from their origin.

Dr. C. G. Knott writes about these observations as follows :—'The other day I took another and more careful look at your curves, and I must confess that they bear out your old view of the large waves being surface waves better than anything else. The large wave curve is a straight line,

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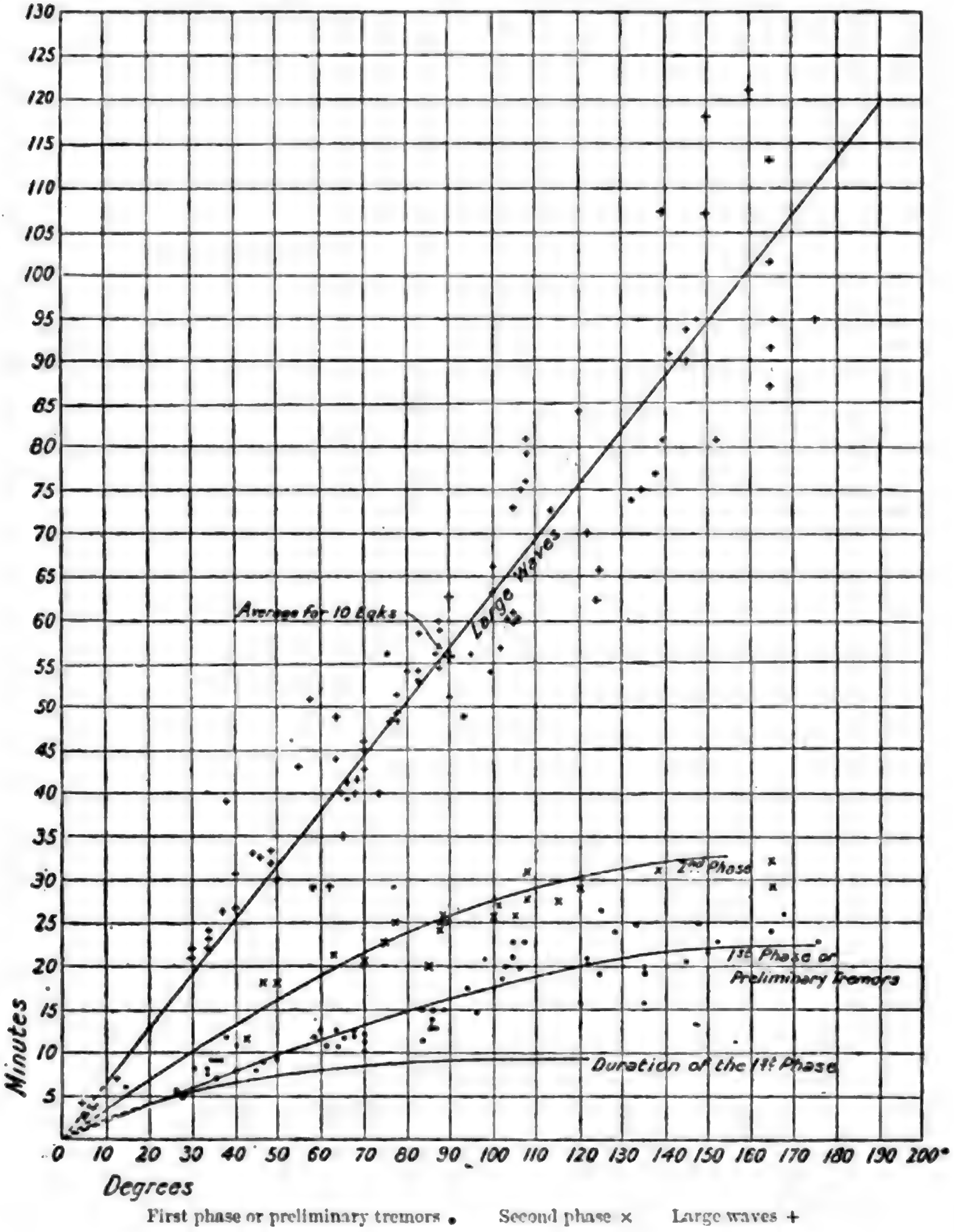
[1] *Phil. Trans. Roy. Soc.*, p 163.

FIG. 3.—Time curves for earthquakes recorded between 1896 and 1900 inclusive.



and though we could formulate a law which would make through-earth waves reach the different points of the surface in times proportional to the arcs, yet it would be a most complicated and improbable law. There is no doubt the surface run fits in admirably. I always had great difficulties about it, but "facts are chiels that winna ding," and the most obvious interpretation of your curve is your old view of surface waves. I never could bring myself to believe in the transition of such small oscillations through the heterogeneous crust. It is conceivable, however, that what we observe may be the outcrop of waves running over the surface of the inner more homogeneous nucleus. This may not be necessary. Meanwhile I am compelled to withdraw my antagonism to the surface wave.

'The preliminary tremor curve fits to within the errors of observation the formula time $\propto$ chord.

'The chord is proportional to sine of half the angle. Tabulating we get :—

Arc	$\frac{\text{Time observed}}{\text{Time to Antipodes}}$	Sin ½ Arc	$\frac{\text{Time observed}}{\text{Time to Antipodes}}$
20	·17	·174	·20
30	·26	·259	·30
40	·35	·342	·39
50	·44	·423	·487
60	·51	·500	·57
70	·58	·574	·65
80	·64	·643	·72
90	·70	·707	·78
100	·76	·766	·83
110	·82	·819	·87
120	·87	·866	·91
130	·91	·906	·94
140	·95	·940	·96
160	·98	·985	·99

'The fourth column gives the same comparison for the second curve, what you call the second phase. In calculating the ratios of the times I take 23 minutes to be the time to the antipodes in the case of the first phase and 33·5 minutes for the second phase.

'You will see how admirable the agreement is for the first phase. But it is not so good for the second phase. The first phase runs at practically the same rate along the chords. The second phase seems to run a little more quickly the deeper they go.'

Tables of apparent velocities based on observations prior to the end of 1896 are given in the 'British Association Report' for 1897, p. 173. These are discussed in the Report for 1898, p. 221, where a table shows that the apparent *arcual* velocity for preliminary tremors varies with the square root of the average depth of the chord. In the report for the following year, p. 231, the preliminary tremors are referred to as passing *through* the earth with an average velocity which increases with the square root of the average depth of the chord along which they are assumed to travel. Whilst pointing out the inaccuracy of this reference, it must also be observed that the variable velocity it implies is not sustained by observations here published.

VI. *On the Comparison of Records obtained from three Horizontal Pendulums at Shide, the Natural Periods of which have from time to time been altered.*

The instruments referred to are the photographic recording pendulums described on p. 60. Their records are compared in the following table. The type of pendulum which records east-west motion is referred to by the letter A. The pendulum with the short boom, also recording east-west motion, and forming part of the Yarrow instrument, is referred to as B, whilst the north-south boom of the same is called C.

Pendulum A has been kept with a period of 17 seconds, whilst the periods of B and C have from time to time been changed.

The numbers in the first column refer to different earthquakes recorded between January 1 and June 30, 1902, as entered in the Shide Register (see Circular No. 6). In the next three columns are the differences in minutes at which A, B, and C respectively commenced to move.

The first entry for Earthquake No. 572 means that A and B show commencements of movement 4 minutes later than C, beneath which there is a zero.

Amplitudes are also referred to under three columns marked A, B, and C. They indicate half the complete range of the maximum motion. Values less than one millimetre refer to the thickening of the line, and indicate half its width.

Durations of the different earthquakes are given in the last three columns. They are expressed in minutes :—

—	Differences in times of Commencement			Amplitudes			Durations		
	A	B	C	A	B	C	A	B	C
Periods . .	s. 17	s. 17	s. 18	s. 17	s. 17	s. 18	s. 17	s. 17	s. 18
	M.	M.	M.	MM.	MM.	MM.	M.	M.	M.
572	4	4	0	1·0	2·0	3·0	115	140	180
573	5	5	0	0·25	0·25	—	5	10	—
574	0	8	6	0·5	0·5	1·0	70	60	65
575	—	not visible		0·25	not visible		10	—	—
576	1	0	0	0·5	0·25	0·25	38	10	45
577	0	1	1	0·25	0·25	0·25	8	5	5
578	97	0	0	0·25	0·5	0·5	45	120	120
579	—	not working		0·25	—	—	5	—	—
580	0	1	1	0·25	0·5	0·5	25	35	35
581	0	3	3	0·5	2·0	2·0	120	230	150
582	0	2	13	0·25	0·5	0·25	45	50	20
583	9	3	0	0·5	0·75	1·0	45	45	55
Periods . .	s. 17	s. 10	s. 10	s. 17	s. 10	s. 10	s. 17	s. 10	s. 10
584	0	3	3	1·0	0·5	0·6	80	65	60
585	0	41	1	1·0	0·25	0·4	60	20	60
586	—	air tremors		0·5	—	—	100	—	—
587	—	"	"	0·5	—	—	90	—	—
588	2	0	0	2·0	1·0	1·0	70	60	60
589	—	not working		1·0	—	—	90	—	—

—	Differences in times of Commencement			Amplitudes			Durations		
	A	B	C	A	B	C	A	B	C
Periods . .	s. 17	s. 12	s. 16	s. 17	s. 12	s. 16	s. 17	s. 12	s. 16
590	7	0	47	0·25	0·25	0·25	44	10	15
591	0	16	58	0·25	0·25	0·25	5	5	5
592	18	0	9	0·5	0·25	1·0	25	30	40
593	9	0	15	0·75	0·5	1·0	90	120	120
594	13 ?	0	0	—	0·25	0·25	—	10	10
595	0	11	air trems.	0·25	0·25	—	25	5	—
596	51	0	46	0·25	0·25	0·25	30	35	120
597	0	3	0	0·5	0·25	0·25	25	5	7
598	0	9	air trems.	0·25	0·25	—	10	5	—
599	6	10	0	1·0	0·75	2·5	50	35	75
600	9	not visible	0	0·25	not visible	0·25	20	—	30
601	37	0	40	1·0	1·2	1·2	140	140	165
602	not visible	—	not visible	—	0·25	—	—	7	—
603	,,	—	faint	—	0·25	—	—	5	—
604	0	0	,,	0·25	0·25	—	5	5	—
605	3 ?	faint	0	0·5	—	0·75	65	—	85
606	0	0	0	6·0	2·5	8·0	180	90	180
Periods . .	s. 17	s. 17	s. 12	s. 17	s. 17	s. 12	s. 17	s. 17	s. 12
607	0	32	not visible	0·25	1·0	not visible	5	12	—
608	0	0	faint	1·0	0·75	0·25	40	40	—
609	0	1	6	1·7	1·0	0·25	72 to 85	28	12
Periods .	s. 17	s. 20	s. 10	s. 17	s. 20	s. 10	s. 17	s. 20	s. 10
610	0	3	not visible	0·5	0·5	—	20	20	—
611	3	air trems.	0	0·75	—	0·5	35	—	12
612	2	0	2	1·0	1·5	0·5	40	40	25

When examining the above table it must be remembered that pendulum C is oriented at right angles to A and B, that the stiffness of the column carrying A is slightly greater than that carrying B, and also that these two pendulums have not always been so adjusted as to have the same sensibility to the effects produced by tilting. It must also be borne in mind that preliminary tremors are but small movements, and their visibility will vary with the width of the photographic trace, whilst many of the entries referring to amplitudes of 0·25 millimetre are markings so slight that they might easily escape detection.

When the periods of A and B were 17 seconds (572 to 583 and 607 to 609) out of thirteen records, the differences in time at which these instruments commenced to record did not exceed 1 minute in seven cases, and there are two cases where the differences are 2 and 3 minutes. In the remaining four cases the differences are respectively 8, 97, 6, and 32 minutes. When the period of B was changed to 10 and then to 12 seconds, it seems to have been, out of eighteen cases, a matter of chance as to which of the two pendulums first responded to the movement of the ground. Twice they commenced simultaneously, and three times the difference in the commencements was from 2 to 3 minutes. In all other instances these differences are large. The times at which pronounced phases of movement have taken place—for which tables are not given—are practically identical for all the pendulums.

In comparing amplitudes when the periods of A and B were equal (17 sec.), the amplitudes were either equal to each other or that for B was larger by 0·25 mm. The only exceptions are for Earthquakes 608 and 609.

When B was reduced to 10 and then to 12 seconds the amplitudes were for all the larger disturbances, excepting 601, distinctly smaller than those recorded by A. In other instances, relating to small earthquakes, these displacements were equal.

A similar relationship between amplitude and period is seen when comparing C and B.

This result is one which does not accord with the result of a somewhat similar experiment made by Dr. F. Ōmori, whilst it does accord with the hypothesis that the large waves of earthquakes traverse the surface of the earth in undulations.

With equal periods for A and B, generally the latter was caused to move for a longer time than the former, whilst when B was rendered more stable this result was usually reversed. This again suggests that the movements recorded are accompanied by tilting.

VII. *Clinometric Experiments.*

In 1891, whilst resident in Japan, I designed a clinometer to record the tiltings of the ground which take place with severe earthquakes within two or three hundred miles of their origin. The chief feature in this instrument was a balance beam loaded at its extremities, which when its frame was tilted in a direction at right angles to its length was assumed to retain its horizontality. A pointer like that of an ordinary balance attached to this beam acted as a steady fulcrum for the short arm of a lever, the outer end of which rested on a smoked-glass surface.

This is described, and illustrations of its records are to be found in the 'British Association Report for 1893,' and in the 'Seismological Journal,' ii. p. 103.

In 1900 and 1901 at Shide, in the Isle of Wight, I set up a similar but much larger clinometer, with the expectation that it would give some definite information about the so-called large waves which are assumed to accompany large earthquakes when they have radiated to great distances. This 'experiment,' which is referred to in the 'British Association Report' for 1900, p. 83, consisted in observing the movements of a pointer attached to the earth relatively to a pointer, 4 feet in length, attached at right angles to the beam of a balance, the arms of which were 5 feet in length, and each carried a load exceeding 30 lb. Any relative movement of these pointers was shown by the displacement of a spot of light reflected from a mirror hung by a bifilar attachment between the two pointers. Subsequently the record was made mechanically.

With the first installation 1 mm. deflection $= 0''\cdot 7$, and in the second $6''\cdot 0$.

Although several large earthquakes took place, no record was obtained.

About the same time Dr. Wilhelm Schlütter (see his 'Inaugural Dissertation,' Göttingen, 1901) experimented with a balance form of clinometer. The records were photographic, but his photograms failed to give any trace of twenty earthquakes recorded by seismographs.

VIII. *Experiments with a Vertical Spring Seismograph.*

With the object of at least detecting the vertical component of the large waves which accompany unfelt earthquakes, in March 1901 I suspended from the wall of my laboratory an ordinary spiral spring, 1 inch in diameter, which, under the influence of a load of 1 lb. 8 oz. and its own weight, was 3 feet 5 inches in length. Its period was then 2 seconds. By the rising or falling of the weight a small mirror was caused to rotate, which displaced a spot of light it reflected upon a moving photographic surface.

'The earthquake of October 9, 1900, caused ripples on the photogram each about 0·5 mm. in range, which would correspond to a change that might have been produced by increasing and decreasing the load by $\frac{1}{700}$ part of itself. The period of motion was approximately 6·5 minutes, which corresponded with the period of maxima in the large waves as in an ordinary seismogram.

The Venezuela earthquake of October 29 gave deflections of half the above, and with periods of about 7 minutes. Other earthquakes caused somewhat similar movements, but usually nothing more than slight blurs upon the photographic traces were to be seen.

The records from the clinometer indicate that earth tilting has not been measurable by the instrument employed, whilst the records from the spiral spring show that there is a possibility that vertical motion may exist, but if it does it is exceedingly minute.'

IX. *On the Nature of Earthquake Movement as recorded at a great distance from its origin.*

In an article in 'Nature,' January 2, 1902, p. 202, after epitomising the various observations which have been made in connection with the large waves of earthquakes, it is said that

'The general inference is that the large waves due to earthquakes originating at a distance, whether they are surface waves or mass waves, actuate horizontal pendulums by horizontal displacements of the ground, rather than by the tilting of the same.'

Observations which support this view are as follows :—

1. Clinometers have hitherto failed to detect any tilting effects.
2. If it is assumed that the records of horizontal pendulums give angular values for tilting, and from the period of the waves causing these tiltings and the velocity with which these waves are propagated on the assumption of simple harmonic motion we calculate their length, we have

all the elements which are required to calculate the heights of these waves.[1] Now these heights are frequently as much as 1 or 2 feet, and apparently represent accelerations $\frac{1}{50}$ of gravity. The magnitude of these quantities is certainly sufficient to create a suspicion that the angular values assigned to large waves has hitherto been exaggerated.[2]

3. The slight evidence of vertical displacements afforded by the experiments described on p. 70.

4. Dr. F. Ōmori's observation that the amplitude of seismograms is not dependent upon the sensibilities of the seismographs to tilting suggests that the movements represented by large waves are horizontal rather than undulatory.

5. The smallness and paucity of records obtained from bifilar pendulums.

On the contrary, observations which support a surface undulation hypothesis are the following :—

1. Surface undulations exist in epifocal districts, and these by the movement of water in ponds and lakes, the movements of the bubbles of spirit levels, the apparent movement of stars in the fields of telescopes, and by other phenomena, have been detected in districts many hundreds of miles beyond the epifocal area.[3]

2. The approximately constant velocity of propagation assigned to large waves (see pp. 65 and 67).

3. Observations which show that the magnitude of a seismogram is dependent upon its sensibility to tilting, p. 70. This conclusion is apparently contrary to that arrived at by Dr. Ōmori.

4. The indications of a vertical component of motion, which have been recorded, p. 71.

With these latter observations before us, it seems reasonable to conclude that the large waves of earthquakes have an undulatory character, but the tilting involved is not so great as generally supposed, and in this sense the above quotation from 'Nature' requires correction.

In the seismograms of a large earthquake we have the records of at least two, and probably three, types of movement, and the manner in which they are presented to us depends upon the character of the instrument by which they were recorded. An ordinary *long* period horizontal pendulum shows the preliminary tremors, which are regarded as compressional waves, which have passed through the earth to be recorded as ripples with a small amplitude ; whilst the large waves, which are assumed to be very flat undulations passing round the earth in or beneath its crust, are shown as large displacements, which are magnified effects due to very slight tilting.

The same disturbance recorded by an apparatus, the natural period of which is *short*, but which is provided with indices having a high multiplication, gives records in which the preliminary tremors are large, whilst the large waves are small, if not entirely absent.[4]

X. *Relationship between Rockfolding, Seismic, and Volcanic Activities.*

Lyell remarks in his 'Principles of Geology,' vol. ii. p. 177 (12th edition), that near the Bay of Naples there appears to be a connection between movements of upheaval and a local development of volcanic heat, whilst periods of depression have been concurrent with periods of volcanic quiescence. A glance at the map, fig. 2 (Plate I.), shows that the districts from which large earthquakes originate, or earthquakes which are accompanied by molar displacements, are those in which geological observations indicate that the land surfaces exhibited as ridges have recently been elevated and where history indicates that elevation is yet in progress.

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[1] *Brit. Assoc. Rep.*, 1898, p. 206.

[2] *Ibid.*, 1900, p. 83.

[3] *Ibid.*, 1898, p. 219 ; also 1900, p. 73.

[4] *Ibid.*, 1898, p. 263.

When this elevation takes place in a ridge, it seems likely that its bounding furrow or furrows should be deepened, and direct evidence that this is the case is sometimes to be found in the records of soundings taken before and after great earthquakes. These records give some idea of the magnitude of the sudden changes in configuration which take place in ocean beds, whilst the dynamical efforts which accompany the same are seen in the disturbances caused in oceanic water and the propagation of vibrations from their origin to their antipodes. Another effect which may accompany these sudden adjustments is to relieve volcanic strain, and no better illustration of this can be found than in the volcanic history of the Antilles, which is briefly as follows:—

1692. Port Royal, in Jamaica, destroyed by an earthquake and land sank beneath the sea. St. Kitts erupted.

1718. Violent earthquake in St. Vincent, accompanied by an eruption.

1766–67. Violent earthquakes in the N.E. of South America, Cuba, Jamaica, and many of the West Indian islands. An eruption in St. Lucia.

1797. February 7.—40,000 lives were lost in Quito. There were also shocks in the Antilles. Eruption in Guadeloupe.

1802. Severe shock in Antigua. Eruption in Guadeloupe.

1812. Caraccas ruined by an earthquake. November 11, 1811, violents shocks commenced in the Southern States of North America. Eruptions in St. Vincent and Guadeloupe.

1835–36. Violent earthquakes in Chili and Central America. Eruption in Guadeloupe.

1902. April 19.—Large earthquake in Central America, by which towns were destroyed. About this date Mt. Pelée, in Martinique, smoked and rumbled. May 3 it erupted. Cables were broken and the sea receded on this date, and was again disturbed on the 8th, 19th, and 20th. May 7, eruption in St. Vincent. Other cables were interrupted. May 8, violent eruption of Mt. Pelée. With these eruptions there were many small earthquakes.

Practically, therefore, we see that every volcanic eruption in the West Antilles has been connected with some sudden geotectonic change in its own or in a neighbouring ridge.

The small earthquakes, of which there may be 30,000 in the world per year, do not hold any appreciable relationship to the volcanic activity of the districts in which they occur.[1]

XI. *On the Comparison of Earthquake Registers from Shide, Kew, Bidston, and Edinburgh.*

In the 'British Association Report,' 1901, pp. 44–50, reference is made to a series of earthquake records obtained in the early part of 1901 at Kew, Shide, Bidston, and Edinburgh. These registers and their continuations to the end of that year will be found in the British Association Circulars Nos. 4 and 5. The following comparisons of the records from the above four stations, which are respectively situated on alluvium, chalk, new red sandstone, and a Palæozoic felstone, with the exception of the month of July, when the instrument at Bidston was not working, relate to the remaining eleven months of the year 1901.

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[1] See *Nature*, May 29 and June 11, 1902.

Earthquake Frequency.

At Kew	73	records	were	obtained,	63	of which	were noted	at other	stations.
At Shide	107	,,	,,	,,	90	,,	,,	,,	,,
At Bidston	133	,,	,,	,,	94	,,	,,	,,	,,
At Edinburgh	94	,,	,,	,,	85	,,	,,	,,	,,

Earthquake Duration.—During the period under consideration fourteen large earthquakes were recorded at each of the four stations, and were also recorded at many other stations throughout the world. The total number of hours and minutes during which the instruments at the four British stations were caused to move by these disturbances were as follows :—Kew, 27 h. 40 m. ; Shide, 31 h. 56 m. ; Bidston, 30 h. 25 m. ; Edinburgh, 31 h. 59 m.

Amplitudes.—For the above fourteen earthquakes the sum of the amplitudes in millimetres recorded at the four stations were as follows :—Kew, 42·8 mm. ; Shide, > 58·4 mm. ; Bidston, 56·7 mm. ; Edinburgh, 40·7 mm.

The inferences to be drawn from the above three analyses are by no means clear.

The Frequency Table apparently shows that at Shide and Bidston more earthquakes can be recorded than at Edinburgh and very many more than can be recorded at Kew. Reference to the registers of these four stations shows that the omissions in the Edinburgh and Kew lists relate to earthquakes which were comparatively feeble.

Not only are the records at Kew few in number, but the duration of a given set of earthquakes as recorded at that station is shorter than the duration of the same set of earthquakes as recorded at other stations.

A much more marked difference between these four sets of records is to be seen in the Table of Amplitudes, which it must be noted have been entered as horizontal displacements. From these records the inference is that the extent of movement at Edinburgh and Kew is much less than it is at Shide and Bidston. Inasmuch as the foundations at the first two mentioned stations are respectively harder and very much softer than the foundations at the two second stations, it seems improbable that the differences in amplitude here recorded are to be altogether attributable to the geological character of the materials on which these four stations are situated.

A more likely cause resulting in these apparent differences in amplitude, and we may add also the differences in durations of movement and number of records, is to be found in differences in the sensibilities of the instruments at the four stations.

If as a measure of the sensibility of an instrument we take the angle through which the bedplate of the same has to be tilted to produce a deflection of one millimetre of the outer end of the boom which it carries, then the sensibilities of the instruments at the four stations under consideration have been as follows :—

At Kew	the sensibility	has varied from	0″·7 to 0″·8, average 0″·75.
At Edinburgh	,,	,, been	0″·71.
At Shide	,,	,, ,,	0″·47.
At Bidston	,,	,, ,,	0″·4 up to June 30 and subsequently 0″·3.

Inasmuch as the instruments with the least sensibility might fail in recording certain very small earthquakes which might disturb an instrument with a higher sensibility, and that the instruments with the lower sensibility would not move so long or be displaced so far whether the motion was horizontal or angular, as would be the case with instruments the booms of which were more easily displaced, it appears that what has been recorded finds its best explanation in the assumption that the same is due to differences in the sensibilities of the apparatus employed.

If we assume that the amplitudes given in millimetres are quantities to be represented in angular measure, then the displacements at the four stations may be stated as follows :—

Kew, 32″·1 ; Edinburgh, 28″·4 ; Shide, 27″·4 ; Bidston, 19″·0.

One inference from this is that the installations at which it was first supposed there was the feeblest seismic sensibility are those at which it is most marked.

Observations are now being made at these four stations with the instruments so adjusted that a 4° turn of the calibrating screw results in a deflection at the outer end of the pendulum of 14 mm., which means that they have equal sensibilities to tilting although their periods may differ (see p. 60).

XII. *An Attempt to Detect and Measure any Relative Movement of the Strata that may now be taking place at the Ridgeway Fault, near Upway, Dorsetshire. Third Report by* HORACE DARWIN, *August* 1902.

In the last Report a hope was expressed that the alterations made in the apparatus had prevented the water getting into the oil vessels ; this has not been the case, water again having blocked the pipes connecting them. It is probable that water enters in the form of vapour and condenses, and as we saw no way of preventing this we decided to replace the oil by a saturated solution of common salt ; an overflow was arranged, and it is hoped that there will be no more trouble from this cause. It was also discovered that the pipe connecting the vessels was not quite straight, and that slight undulations in it prevented the free flow of the liquid ; this is being rectified.

Magnetic Observations at Falmouth.—Report of the Committee, consisting of Sir W. H. PREECE (*Chairman*), Dr. R. T. GLAZEBROOK (*Secretary*), Professor W. G. ADAMS, Captain CREAK, Mr. W. L. FOX, Professor A. SCHUSTER, *and* Sir A. W. RÜCKER, *appointed to co-operate with the Committee of the Falmouth Observatory in their Magnetic Observations.*

THE Committee report that the grant voted at the last meeting of the Association has been used in support of the ordinary magnetic work of the Falmouth Observatory, and that records of the horizontal force and declination have been kept during ten years. The curves up to the end of 1901 have been examined at Kew, and the results are of real value. The vertical force instrument has been a cause of some difficulty ; the examination of the 1901 curves led Dr. Chree to suspect the existence of a very large and anomalous temperature coefficient. Experiments at Falmouth confirmed this and showed, moreover, the curious fact that the change following a rise of temperature reversed its sign as the heating continued. The instrument was dismounted and sent to Kew for examination in April last. Experiments made by heating the room containing the apparatus confirmed those made at Falmouth as to the enormous size of the apparent temperature coefficient; and finding it impossible to alter this appreciably, it was arranged to increase the weight on the compensation bar and make some other changes.

Even when the instrument was returned the anomalous behaviour continued, and finally it was shown that by far the largest part of the effect was due in some way to the method in which the mirror was attached to the magnet. A change of temperature had the effect of binding or twisting the mirror, and most of the effect was due to this. This difficulty was remedied, but the magnet has only just been returned; hence it is impossible as yet to say whether it is completely satisfactory or not; but there is every reason to suppose that this will be so.

With regard to the special work of co-operating with the Antarctic Expedition, while it was not found possible to arrange for special quick views of the Falmouth instruments on the term day, Mr. Kitto undertook to take such share as was possible with the existing instruments, and the Secretary sent directions to him as to how this might be done. On this point Mr. Kitto reports :—

1. Care has been taken to prevent as far as possible any local disturbance of the magnetic instruments during 'term days.'
2. The curves for the term days have been run without interruption, and hourly measurements will be made of these.
3. The temperature has been maintained as constant as possible.
4. The scale values have been determined with care.
5. Absolute determinations have been taken (as far as possible) on the second, fourteenth, sixteenth, and last days of each month.

The Committee are of opinion that they should be reappointed and that a further grant should be made to them for the continuance of the magnetic work at Falmouth.

The reasons for this are twofold :—(i.) It has not been found possible as yet to establish the new magnetic observatory and to remove the recording instruments from Kew; at the same time the increase in electrical traction to the south-west of London has caused a distinct increase in the disturbances. Dr. Chree reports that the comparatively quiet interludes seem fewer and the mean width of the braces larger in all the elements; thus the diurnal variation results for horizontal force and declination at Falmouth in view of the disturbances near London are of distinct importance until the new station has been established. (ii.) The special period of magnetic research for the Antarctic lasts until March 1903 at least, and it is desirable to keep up the Falmouth records during the whole of this period.

In conclusion, therefore, the Committee beg leave to recommend that they be reappointed, with a grant of 100*l*.

Investigation of the Upper Atmosphere by Means of Kites in co-operation with a Committee of the Royal Meteorological Society.—Report of the Committee, consisting of Dr. W. N. SHAW (*Chairman*), Mr. W. H. DINES (*Secretary*), Mr. D. ARCHIBALD, Mr. C. VERNON BOYS, Dr. A. BUCHAN, *and* Dr. H. R. MILL.

I.

THE Committee submit the following notes, drawn up by the Secretary:—

On the invitation of the Committee appointed by the Royal Meteorological Society it was decided to hold joint committee meetings, and such meetings were held on October 25, 1901; January 14, April 8, and May 7, 1902.

The sum of money at the disposal of the joint committee, viz., 75*l.* granted by the British Association and 25*l.* by the Royal Meteorological Society, not being sufficient to meet the necessary expenses, it was decided to apply to the Meteorological Council and to the Government Grant Committee of the Royal Society for further assistance. The Meteorological Council kindly undertook to supply the necessary instruments for a base station, and the Government Grant Committee have made a grant of 75*l.*

Inasmuch as there is considerable risk of damage and also of injury to life should a long wire carrying one or more kites break loose in a thickly populated district, it was decided to make observations in some thinly inhabited part, and, if possible, over the sea, so as to reduce this risk to a minimum. Furthermore, as we have no information whatever as to the vertical temperature gradient over the great oceans, and this knowledge is of supreme importance for theoretical meteorology, it seemed desirable to work on the west coast, since the prevailing westerly winds must make observations taken there equivalent, as a rule, to those taken over the open sea. It was also thought that if a fair number of observations could be obtained at the height of Ben Nevis, but somewhere on the coast in the neighbourhood of Ben Nevis, some light would be thrown upon the question as to how far the temperatures taken on a mountain summit differ from the temperatures of the free air in the surrounding districts at the same level.

With these objects in view I was commissioned to obtain the necessary apparatus and erect it at some convenient spot on the west coast of Scotland.

The apparatus has been obtained and is now (June 17) erected on a small island at Crinan, a small village lying at the north end of the Crinan Canal, about thirty miles south of Oban.

The apparatus consists of—

I. Winding-in apparatus for the wire.
II. Engine and boiler to drive the same.
III. Set of kites.
IV. Twelve miles of steel music-wire.
V. Instruments.

I. The winding-in apparatus carries two reels of 16 inches diameter and 4 inches broad, to hold the wire, and two strain-pulleys to reduce the tension of the wire before it is wound. The reels run loose on the same shaft that carries the strain-pulleys, but there is an arrangement by which they are pressed automatically against the strain-pulleys to increase their turning moment by friction against the outer rim of the pulley, or against the fixed frame of the apparatus to reduce the moment. By this means an adjustment of the tension is obtained, and the risk of the reel being crushed by the tension of the many turns of the wire is avoided.

II. *Steam-engine.*—This was obtained from the Reading (U.S.) Road Car Company. It has four single-acting cylinders of 2½-inch bore and 4-inch stroke. It weighs about 60 lb. and is nominally of 6 H.P. The cost was 25*l.*

The choice lay between a steam-engine and a petrol motor. The steam-engine was chosen for the following reason. It is not desirable to draw in a kite wire, when the wire is near the breaking-point, at a uniform speed, because the speed of winding in is equivalent to an increase of the wind velocity, and greatly adds to the strain. Advantage should be taken of the intervals between the gusts to get in the wire, and this a steam-engine without a dead point does automatically. Winding in a kite during a gale on June 14 the engine acted perfectly, running fast whenever the tension of the wire slackened, and slowing down or even stopping entirely when the tension was increased by a gust. Of course the precise tension at which the engine stops is adjustable within wide limits by adjusting the steam pressure in the boiler.

The boiler was obtained from the Britannia Company, Colchester, at a cost of 25*l.* It is fired by ordinary lamp oil (paraffin), of which it uses about a gallon an hour.

III. *The kites.*—These are described in Symons' 'Meteorological Magazine' for April, where also the reasons for not using the Blue Hill kite are stated.

Of these there are five ready for use and the materials for making six or eight more. There are also two kites designed by, and purchased of, Mr. F. S. Cody.

Both kinds, so far as my present experience goes, seem entirely satisfactory. Mr. Cody's kite flies at a rather better angle, but does not seem to be quite as steady as the other. Indeed, the angle of the Cody kite when made of silk and light bamboos is remarkably good.

IV. *The wire.*—This is of the usual kind, but I have been supplied with eight miles in one piece by Messrs. Brunton and Son, Musselburgh, N.B.

V. In addition to the well-known Richard instruments which have been ordered, it seemed desirable to obtain, if possible, something cheaper, since the risk of losing the instruments is not small. I am experimenting with a cheaper form. I also hope to obtain correct determinations of the maximum height and the temperature at that height in the following manner. If a glass tube of uniform bore, sealed at the top, but with the other end under water or quicksilver, were sent up with a kite, it would, assuming constant temperature, give the maximum height, for the air in the tube, under the decreased pressure, would expand and bubble out, and on the descent water would rise in the tube, and the height of the water or quicksilver would give the minimum pressure, and hence the maximum height. This is assuming constant temperature. But if an exactly similar tube were also used containing saturated vapour of alcohol, two equations would be obtained, from which the two unknown quantities, temperature, and height can be determined. I hope to perfect this method, since there are many occasions on which a kite and a couple of glass tubes might be risked when one would hesitate to send up instruments costing 20*l.*

The apparatus above described is now in use every day when the wind is suitable, but there seem to be very many days during the summer when a sufficiently strong wind does not occur. A velocity of about fifteen miles per hour is necessary, force 4 on the Beaufort scale; but the upper limit at which the kites will fly has not yet been determined.

II.—*Addendum, August* 22.

Up to August 20 sixty-eight flights have been obtained, as shown in the following table :—

Date	Time	Greatest Height	Temperature Gradient per 1,000 feet	Wind Direction		Length of Wire used	No. of Kites
				Above	Below		
		Feet	° F.			Feet	
June 19	11 50 A.M.	2,840	3·8	S.	E.	5,000	1
„ 20	11 0 A.M.	3,300	—	S.E.	S.E.	5,000	1
„ 21	11 0 A.M.	3,300	—	S.E.	S.E.	4,515	2
„ 24	11 0 A.M.	2,100	5·7	S.S.E.	S.S.E.	—	1
„ 24	7 0 P.M.	2,300	—	S.S.E.	S.S.E.	5,000	1
„ 26	11 0 A.M.	4,600	—	S.S.E.	S.E.	7,500	1
July 1	11 0 A.M.	1,850	—	N. by E.	N.N.W.	3,000	1
„ 3	12 45 P.M.	2,500	4·5	N. by E.	S.S.W.	4,000	1
„ 4	7 0 P.M.	2,250	3·0	N.N.W.	N.N.W.	3,560	1*
„ 7	11 0 A.M.	4,600	2·2	W.	W.	7,330	1*
„ 8	11 0 A.M.	2,000	1·8	—	S.S.E.	—	1*
„ 9	12 0 M.	4,950	3·3	S.W.	S.W.	9,000	2*
„ 9	6 10 P.M.	2,300	3·9	—	W.	4,000	1
„ 10	4 0 P.M.	4,040	2·3	N.N.W.	N.W.	7,000	1
„ 11	12 30 P.M.	1,800	—	—	—	—	1
„ 11	6 50 P.M.	1,350	0·8	—	W.	2,300	1
„ 12	5 0 P.M.	1,300	1·5	—	S.W.	—	1*
„ 14	6 0 P.M.	1,950	—	S.W. by W.	S.S.W.	—	1
„ 15	11 0 A.M.	6,400	3·1	S.W. by W.	S.W.	10,300	2*
„ 15	5 0 P.M.	4,300	2·8	S.W.	S.W.	—	1*
„ 16	12 5 P.M.	6,000	2·0	W.S.W.	S.W.	10,300	2*
„ 17	11 45 A.M.	3,160	2·9	—	W.	—	1*
„ 17	5 30 P.M.	3,600	3·3	N.N.W.	N.W.	—	1*
„ 18	1 0 P.M.	5,000	3·6	N.N.W.	N.W.	—	2*
„ 19	6 55 P.M.	3,400	2·6	N.N.W.	N.W.	6,000	1
„ 21	11 0 A.M.	1,170	4·3	N.N.W.	N.N.W.	—	1
„ 21	7 55 P.M.	3,000	2·7	N.W.	W.	6,200	2*
„ 22	4 45 P.M.	1,330	—	N.N.W.	W.	—	1
„ 23	10 40 A.M.	1,750	3·4	N.N.W.	N.W.	—	1
„ 23	6 45 P.M.	2,230	—	N.W.	N.W.	3,225	1
„ 24	11 45 A.M.	4,000	4·2	N.	N.N.W.	7,000	2
„ 24	5 20 A.M.	4,760	3·6	N.W.	W.N.W.	10,600	2*
„ 25	11 0 A.M.	2,450	—	—	W.	4,200	1
„ 25	7 30 P.M.	1,320	—	—	N.W.	2,020	—
„ 26	11 0 A.M.	4,330	3·5	E.	E.N.E.	5,450	1*
„ 26	7 0 P.M.	5,500	2·3	E.N.E.	N.E.	10,200	2*
„ 28	12 0 M.	7,350	3·3	S.W. by W.	W.S.W.	12,000	2
„ 28	7 30 P.M.	5,000	2·5	S.S.W.	S.S.W.	8,100	1*
„ 29	12 30 P.M.	4,325	2·7	W.	W. by S.	8,200	1*
„ 29	7 40 P.M.	5,330	3·1	W.	W.S.W.	8,412	1*
„ 30	12 10 P.M.	8,950	2·7	N.N.W.	N.W.	17,300	2*
„ 31	11 0 A.M.	1,560	3·6	—	N.N.W.	—	1*
„ 31	6 20 P.M.	1,550	—	—	W.	—	1
Aug. 1	11 0 A.M.	2,400	4·1	W.S.W.	S. by W.	—	1
„ 1	7 30 P.M.	8,550	1·7	W.S.W.	S.S.W.	16,000	2*
„ 2	11 30 A.M.	8,370	2·1	S.W. by W.	S.W.	13,500	2*
„ 2	5 10 P.M.	4,900	2·5	—	S.W. by W.	7,530	1*
„ 4	4 0 P.M.	1,520	—	—	W.	—	1
„ 5	11 30 A.M.	1,840	—	—	E.	—	1
„ 6	1 30 P.M.	3,800	3·5	E.S.E.	E.	6,900	1*
„ 7	11 0 A.M.	2,725	5·0	E.N.E.	N.E.	4,300	1

Date	Time	Greatest Height	Temperature Gradient per 1,000 feet	Wind Direction		Length of Wire used	No. of Kites
				Above	Below		
		Feet	° F.			Feet	
Aug. 8	11 40 A.M.	1,300	4·0	—	N.N.W.	—	1
„ 8	5 20 P.M.	6,900	3·5	N.W.	W.N.W.	12,000	2*
„ 9	11 0 A.M.	2,360	3·7	—	W.N.W.	—	1
„ 9	4 40 P.M.	7,175	3·1	N.W.	W.N.W.	13,000	2*
„ 11	1 20 P.M.	7,425	2·4	N.W.	N.W. by W.	18,000	3*
„ 12	10 10 A.M.	4,080	3·5	N. by W.	N.W.	7,375	1
„ 12	4 15 P.M.	1,550	1·5	—	W.S.W.	2,900	1*
„ 13	3 0 P.M.	1,350	3·0	S.E.	S.	—	1
„ 14	4 30 P.M.	1,950	1·8	W.	W.	—	1
„ 15	11 30 A.M.	2,300	3·9	S.W.	W.	3,900	1
„ 15	6 30 P.M.	1,415	—	S.W.	W.	2 500	1
„ 16	11 30 A.M.	1,400	1·8	N.N.W.	N.W.	2,190	1
„ 18	2 30 P.M.	2,750	4·3	N.N.W.	N.	4,980	2
„ 19	11 10 A.M.	4,250	3·9	N.N.W.	N.W.	7,100	2
„ 19	3 30 P.M.	4,400	3·8	W.N.W.	N.W.	9,537	2*
„ 20	12 10 P.M.	11,450	2·4	N.W.	N.W.	21,350	3*
„ 20	7 20 P.M.	4,000	4·5	W.N.W.	W.	7,100	1

In the cases marked * records from Richard Frères' instruments were obtained, in the others the temperature at the highest point only.

For the period extending from July 8 to August 22 a steam-tug was obtained, and the apparatus mounted on the deck. This arrangement was found to give much more effective control over the experiments, and rendered possible observations in light winds that would not have lifted the kites on land. The observations will be discussed and the results prepared for publication in the course of the ensuing year.

III.

The Committee consider that the work which has been completed is amply sufficient to show that the apparatus and methods are effective for securing valuable information as to the upper air in various conditions of weather. There are some points in which it seems desirable to attempt to improve the recording apparatus in order that the readings may be more definitely checked, and the Committee think it desirable for the experiments to be continued for another year, during which it may be possible to so arrange the flights as to obtain precise information regarding the distribution of temperature and humidity in specific conditions of weather in order to examine the physical processes taking place in the upper air corresponding to weather changes noted at the surface.

The kites and apparatus for winding in, with such modifications as experience has suggested, but with little additional cost, will be available, but it is of great importance to be able to employ a tug, in order that the investigation of the upper air may not be entirely dependent upon windy weather.

The Committee therefore ask for reappointment, with the addition of the names of Dr. Glazebrook and Professor Schuster, and a grant of 100*l*.

Report on the Theory of Point-groups.—PART II.

By FRANCES HARDCASTLE, *Cambridge.*

CONTENTS.

PAGE
§ 5. The Title of the Report 81
§ 6. General Historical Introduction 81
§ 7. The Theory of Elimination, from Leibnitz to Cramer, 1693–1750 . . . 83
§ 8. Memoirs on the Intersections of Plane Curves, from Maclaurin to Lamé, 1720–1818 90

§ 5. THE TITLE OF THE REPORT.

THE first instalment of this report is printed in the 'British Association Report' for 1900 under the title 'A Report on the Present State of the Theory of Point-groups.' In view, however, of the space it has been found necessary to assign to the historical development of the subject, this title has been changed by the omission of the words limiting its scope to contemporary times. The sections of which the present instalment consists are numbered consecutively with Part I. After a short general introduction (§ 6) and a section on the Theory of Elimination (§ 7) the first period of the historical outline given in § 2 is expanded in § 8.

§ 6. GENERAL HISTORICAL INTRODUCTION.

In the middle of the seventeenth century two men's names stand out prominently in the history of pure mathematics. Descartes (1596–1650) and Fermat (1601–1665), both Frenchmen, were born within five years of each other, and although the exclusive epithet of Cartesian has been bestowed by posterity upon the technical device which each independently invented for the treatment of geometrical problems, it is doubtful whether Fermat's ideas were not of wider significance,[1] and in the investigations which bear most on our purpose he certainly showed the greater insight, notwithstanding certain unfortunate deviations from fact in his criticism of his rival.[2]

The paper containing Fermat's exposition of the method of coordinates[3] begins by a detailed investigation of the equations of a straight line and of each of the conic sections in turn, but carries this idea no further. In his prefatory words, however, we note his realisation of the possibility of a more general application of the method: 'Toutes les fois que dans une équation finale on trouve deux quantités inconnues, on a un lieu, l'extrémité de l'une d'elles décrivant une ligne droite ou courbe. . . . Toutes les fois que l'extrémité de la quantité inconnue qui décrit le lieu suit une ligne droite ou circulaire, le lieu est dit *plan*; si elle décrit une parabole, une hyperbole ou une ellipse, le lieu est dit *solide*; pour d'autres courbes on l'appelle lieu *de ligne*. Nous n'ajouterons rien sur ce dernier cas, car la connaissance des lieux *de ligne* se déduit très facilement, au

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[1] *Cf.* Cantor, *Geschichte der Mathematik*, vol. ii. p. 745. This learned and withal interesting history supplies much information concerning works published before the year 1758, with which it closes.

[2] Fermat, *Œuvres* (edit. Tannery and Henry, Paris, 1891), vol. i. p. 121, editors' note. *Cf.* also Cantor, vol. ii. p. 744.

[3] 'Introduction aux lieux plans et solides,' *loc. cit.*, vol. i. pp. 91–110 (Latin original); vol. iii. pp. 85–101 (French trans.).

moyen de réduction, de l'étude des lieux *plans* et *solides*.' The terms *plane*, *solid*, and *linear loci* were in general use at that time, with the meanings he attaches to them; the notion of including them all under one law of formation marks his step towards the true analytical standpoint; but the end of the paragraph shows the limitation to which his mind was still subject. In fact, the main interest of the new method to Fermat and Descartes lay in its application to the solution of algebraical equations by means of the intersections of geometrical curves; they did not, apparently, discern that the opposite course would prove the more fruitful, that with a wider knowledge of the theory of algebraical equations future generations would obtain a grasp of the geometry of curves far exceeding that of the ancients.

The slow emergence of the modern standpoint is shown by the lapse of time—nearly seventy years—between the publication of Descartes' 'Geometry' (1637) and of Newton's (1642–1727) 'Enumeratio linearum tertii ordinis' (1704). Here we find stated for the first time the definition, now usually adopted, of the order of a curve, viz., the number of points in which it can be cut by a straight line. Descartes had adopted an unfortunate classification,[1] not according to degree, but according to 'genus': in his parlance curves of the $2n$th and of the $(2n-1)$th degrees belong to the nth genus. This had possibly arisen from his investigations into a celebrated problem of Pappus,[2] or, as Fermat seems to think,[3] from an erroneous conclusion respecting the reduction of an equation of degree $2n$ by one degree. In any case it became a source of error[4] and was tacitly abandoned.

Next in importance to the order of a curve is the number of terms involved in its equation. The statement that the equation of a curve of the nth order contains $\frac{1}{2}n\ (n+3)$ coefficients was first made by James Stirling (1692–1770) in his 'Lineæ tertii ordinis Newtonianæ,' which was published thirteen years after the Enumeratio (*i.e.*, in 1717), and is practically an exposition of and a sequel to Newton's book. Moreover, in the same work[5] Stirling drew attention to the fact that a curve can only pass through $\frac{1}{2}n\ (n+3)$ points, and that it is determined by this number of points, and thus paved the way for the enunciation, three years later (1720), of the so-called Cramer Paradox by his contemporary Maclaurin[6] (1698–1746). This young Scotchman was barely twenty-one when his 'Geometrica organica, sive descriptio linearum curvarum universalis' was published. Short as it is, 140 quarto pages in all, this treatise at once placed its author in the front rank of geometers, and is justly held to be the foundation of the modern synthetic geometry of higher plane curves,[7] in so far as this depends upon theorems dealing with their intersections.

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[1] Descartes, *Œuvres*, edit. Cousin (Paris, 1824), vol. v. p. 338, or *Geometria*, edit. Schooten (Amsterdam, 1659), p. 21.

[2] Cantor, vol. ii. p. 742.

[3] Fermat, vol. i. p. 119 (Latin original); vol. iii. p. 110 (French trans.).

[4] Cantor, vol. ii. p. 44.

[5] P. 69.

[6] For a brief account of the historical oblivion into which the true originator of the paradox had fallen, *cf.* C. A. Scott, *Bull. Am. Math. Soc.*, vol. iv. (1898), p. 261.

[7] Brill and Noether, 'Die Entwicklung der Theorie der algebraischen Functionen in älterer und neuerer Zeit,' *Jahresber. d. deutschen Math. Ver.*, vol. iii. (1894), p. 129. This valuable report is full of suggestive criticism, most helpful to any student of the papers which it passes in review, but its concise language makes it rather difficult reading.

§ 7. The Theory of Elimination, from Leibnitz to Cramer, 1693–1750.

We must go back fifty years before the birth of analytical geometry to find the first appearance of a problem which is fundamental to the theory of elimination in one of its aspects, the problem, namely, of obtaining the greatest common measure of two algebraical expressions. In 1585 a Belgian mathematician, Simon Stevin (1548–1620), published an algebra in which the first successful attempt at a solution was made. He divided one expression by the other, and this again by the remainder, until no remainder is left; the last divisor is then the greatest common measure; the fractions are left as they appear in the course of the work. Vieta (1540–1603), the greatest algebraist of the sixteenth century, wrote a treatise on algebraical equations in 1591 (published, after his death, in 1615), but did not investigate this question. In fact it does not seem to be mentioned again in print for more than a century, when Rolle (1652–1719) gave it a place in his 'Traité d'Algèbre,' published in 1690. By this time abbreviations of the work by means of multiplication and division were probably in use, since we find them freely employed by Reyneau (1656–1728) in his 'Analyse démontrée' of 1708.

In the meanwhile Fermat was attacking the problem of rationalising an equation which Vieta had left in a very unsatisfactory condition, and the method he adopted, although stated as a series of proportion sums in the manner of his time, amounts precisely to the elimination of an unknown from two equations by using the condition that their left-hand sides should have a greatest common measure. The example he gives[1] consists of a cubic and a quadratic equation, each containing one variable which is to be eliminated. Calling these equations $P=0$, $Q=0$, respectively, we may write $P=q_0 Q+R_1$, and R_1 is then the first remainder after dividing P by Q. Fermat's process, however, reverses the usual arrangement of terms in P and Q, writing them in ascending not in descending order, for he arranges his proportions so that the antecedents contain the variable while the consequents are free from it; thus:

$$a_0x^3+a_1x^2+a_2x : a_3=b_0x^2+b_1x : b_2$$

is derived from $P\equiv a_0x^3+a_1x^2+a_2x+a_3=0$

$$Q\equiv b_0x^2+b_1x+b_2=0$$

where in his notation

$$a_0=l,\ a_1=0,\ a_2=0,\ a_3=z^3-a^3$$
$$b_0=l,\ b_1=d,\ b_2=n^2-ab$$

and thus his expression for R_1, after dividing out by the factor x, differs from the usual one by the interchange of a_0 and a_3, a_1 and a_2, b_0 and b_2, and of $\frac{1}{x}$ for x, being in modern notation

$$\begin{vmatrix} a_3 & b_2 & 0 \\ a_2 & b_1 & b_2 \\ a_1 & b_0 & b_1 \end{vmatrix} + \begin{vmatrix} a_3 & b_2 & 0 \\ a_2 & b_1 & b_2 \\ a_0 & 0 & b_1 \end{vmatrix} x$$

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[1] Fermat, *Œuvres* (edit. Tannery and Henry, Paris, 1891) 'Nouveau traitement en analytique des inconnues secondes et d'ordre supérieur,' vol. i. pp. 181–188 (Latin original); vol. iii. pp. 167–163 (French trans.).

This fact is of no importance theoretically, and would be of but slight importance in practice, if the coefficients employed were the most general possible. But when, as in Fermat's example, the coefficients of the highest powers only are unity, the interchange materially complicates the algebra involved in the next stage of division, or in substituting, as he directs, the expression for x obtained from $R_1=0$ in the quadratic equation ; and, presumably for this reason, Fermat left it to the industry of his readers. Moreover, when the substitution has been effected, a further complication arises from Fermat's method : the irrelevant factor[1] which is a necessary consequence of this process is now b_2^2 instead of b_{00}^2 i.e., $(n^2-ab)^2$ instead of unity ; the remaining factor (the resultant) is unchanged, being symmetrical with respect to this interchange of coefficients.

As regards the general application of his method to a system of n equations among $n-1$ unknowns, Fermat remarks : 'Il est clair que la méthode est générale. Si en effet on proposait plus de deux inconnues, la méthode, réitérée autant qu'il le faudra, exprimera par exemple la troisième en fonction de la première et de la seconde, puis la seconde en fonction de la première, toujours par le même moyen.' But we may be permitted to doubt whether the courage of most calculators would not fail in undertaking such an elimination without the assistance of a properly devised notation, of which, at this date,[2] no trace is found.

The emancipation of mathematics from the preliminary stage, in which attention is mainly directed to the solution of particular problems, was being effected during Fermat's lifetime—Kepler and Galileo were his seniors by thirty and thirty-seven years respectively, Descartes and Pascal were his contemporaries—but the chief impulse in this direction was given after his death by Leibnitz (1646–1716) and by Newton. Leibnitz especially saw the cardinal importance of notation. The double suffix notation which he invented (*mehrfacher Stellenzeiger*) was not mentioned in print until 1700, but had been used by him as early as 1678, as is shown by a Latin manuscript note found among his papers after his death.[3] The rule here set down for removing the unknowns from any system of linear equations such as,

$$\begin{gathered}10+11x+12y=0\\ 20+21x+22y=0\\ 30+31x+33y=0\end{gathered}$$

where there is one more equation than there are unknowns, consists in observing the law of combination of the double indicators. A new method for the elimination of the unknowns from two equations of degree higher than the first is then derived from this rule : 'By means of this rule another rule can be found for removing the unknown quantity common to two equations of any degree whatever. Multiply each by an assumed expression of one degree lower, and when these products have been added together, so as to form a single equation, let every term of it be equated to zero ; we thus obtain as many equations as there were coefficients in the assumed expression and one more equation. Hence the former rule can be applied. If the two equations from which the common quantities are to be removed are not of the same degree, the coefficients of the higher orders in the equation of lower order are to be taken as zero.' In a letter to l'Hôpital dated April 28, 1693,[1] Leibnitz refers to this subject, and expresses a desire for tables by which the results of elimination between equations of higher order may be systematically deduced from those of lower order. This is the letter in which he for the first time explained and vindicated the new notation, and it has led most writers [2] to attribute to him the origin of the theory of determinants. However this may be, the Theory of Elimination certainly owes its origin to him, for he was the first to regard it as a matter for separate investigation and to desire its reduction to general laws.

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[1] An ingenious formula for obtaining this factor, in the most general case, is given by Faà de Bruno, *Théorie générale de l'élimination* (Paris, 1859), pp. 47–52.

[2] The date of this manuscript is held to be 1638, although it was not printed until 1679, in the *Varia Opera*, cf. Cantor, vol. ii. p. 734.

[3] Gerhardt, preface to vol. vii. of Leibnitz's *Works* (Berlin, Halle, 1849–63), p. 5.

It would be interesting, were evidence on the subject forthcoming, to think that Leibnitz's new method of elimination had been communicated by him to his friend Tschirnhaus (1651–1708), with whom he was in constant communication on these subjects, and that it is the method alluded to by the latter in his memoir in the 'Acta Eruditorum' of 1683, where he speaks of well-known rules for obtaining a third equation, in which the unknown is absent, from two given ones containing it. But, on the whole, it is more probable that a method of combination and substitution, which amounts to using the condition for the existence of a greatest common measure was in his mind.[3]

Tables of the nature desired by Leibnitz were published by Newton in his 'Arithmetica Universalis' (1707):[4] he gives the actual results of the 'extermination' of a variable from certain typical equations, viz., from two quadratics, from a cubic and a quadratic, from a quartic and a quadratic, and from two cubics, but with no definite account of the steps of his calculation. His method, however, appears to be that of substitution and combination, and is thus essentially different from that of Leibnitz. The arrangement of the terms in the successive results shows an attempt at a systematic derivation of each from the last, but the law is by no means clear. It is noteworthy that in each case the result obtained is given in its simplest form, *i.e.*, the extraneous factor, which is not unity in his notation, has been removed.

Newton gave no rules applicable to equations of order higher than the fourth, and only considered equations involving one unknown. The more general cases of higher equations and two unknowns were attacked for the first time [5] (unsuccessfully, however) by Maclaurin in the 'Geometrica Organica.' Neglecting for the moment the geometrical application for which he required his result, the interest of Section V. of this treatise centres on the attempt to eliminate one unknown between two equations in two unknowns and to determine the dimension of the remaining unknown in the result. In the Lemma with which this section opens one equation only is assumed to be of an arbitrary number of dimensions, n, in x and y, while the second is a quadratic and a cubic equation respectively. Maclaurin substitutes for all powers of the variable y equal to and greater than 2 and 3 respectively in the equation of degree n, and thus obtains equations in y lower by one degree than the lowest of the original pair of equations. In the simpler case (that of the quadratic and the equation of degree n) this gives a value for y, which simply requires substitution in the quadratic in order to lead to the required equation in x—of degree $2n$—and does not introduce any extraneous factor. But when the original system consists of a cubic and an equation of degree n, leading to a system of a cubic and a quadratic in y whose coefficients are functions of x, the process of eliminating y—whether by direct G.C.M. method or by Maclaurin's shortened process of combining the equations, first removing the highest term and then the lowest term—necessarily introduces an extraneous factor which involves x. To find this factor, even with an unsystematic notation, is easy enough in this simple case, and Maclaurin shows, quite correctly, that the irreducible resultant is then of degree $3n$; but he saw clearly that all his knowledge of Newton's 'method of divisors' would not avail him in the completely general case of equations of degrees m and n. He therefore relegates this question to Corollary I., which, freely translated, runs: 'Hence the intersections of lines of order m and n are seen to be mn in number. We have, it is true, hitherto searched in vain for a universal proof of this fact by reason of the difficulty of finding divisors in harder equations.' That he did not employ a better notation is all the more remarkable when we consider that in a chapter of his 'Algebra' (planned about the year 1729,[1] but published, after his death, in 1748) he 'exterminates' the unknowns from systems of two and three linear equations, and gives a rule for four equations which shows his clear appreciation of the symmetry of the result: 'If 4 equations are given, involving 4 unknown Quantities, their Values may be found much after the same Manner by taking all the Products that can be made of 4 opposite Coefficients (i.e., *belonging to different equations and to different variables*) and always prefixing contrary signs to those that involve the Product of two opposite Coefficients.' This is exactly the idea involved in the modern solution by means of determinants. And considering that Leibnitz had insisted on the value of his double suffix notation in the paper in the 'Acta Eruditorum' for 1700,[2] written in reply to a tract published in London, Maclaurin almost seems to have gone purposely out of his way to avoid its use,[3] and, in so doing, perhaps lost a chance of overcoming some of the obstacles to his method of elimination. Even the best possible notation, however, would have been comparatively valueless without the realisation of the intimate theoretical connection between the process of finding the G.C.M. and the problem of elimination, and for this the time was not ripe. The method, or its equivalent, was used in practice, but was not explicitly explained. In fact the only contemporary statement in print on this subject is to be found in a small book on analytical geometry by de Gua de Malves,[1] published in 1740. He remarks[2] that to find the necessary condition in order that certain three equations may hold simultaneously: 'on pourra se servir des formules que M. Newton a données dans son "Arithmétique Universelle," ou, ce qui revient au même, on pourra encore diviser les deux premières équations . . . par leur reste, puis les premiers restes par les seconds, et ainsi de restes en restes jusqu'à ce qu'on soit parvenu à en trouver qui ne contiennent plus l'indéterminée x, ces derniers restes, étant faits égaux à zéro, donneront les équations des conditions.'

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[1] Leibnitz, *Works*, edit. Gerhardt, vol. ii. p. 239.

[2] *Cf.* Gerhardt, *Geschichte der Mathematik in Deutschland*, 1877, vol. xvii. p. 184, and preface to vol. vii. of Leibnitz's *Works*, p. 8. Also Brill and Noether, *loc. cit.*, p. 126, and Salmon, *Higher Algebra*, Note on History of Determinants. It has, however, been pointed out by Stŭdnička (*A. L. Cauchy als formaler Begründer der Determinanten-Theorie*, Prag, 1876) that Cauchy was the first to develop a *theory* of determinants; and it seems scientific to distinguish thus between the invention of a new mathematical machine—the suffix notation, which provides a law of formation for the new coefficients—and the separate discussion of its properties.

[3] Cantor, vol. iii. p. 109.

[4] 1st edit., p. 74.

[5] Fermat realised that curves of the *m*th and *n*th orders lead, by their intersections, to the solution of an equation of degree *mn* (*cf.* Fermat, *Œuvres*, vol. iii. p. 119, vol. i. p. 130, and Cantor, vol. ii. p. 746), but he gave no attempt at a proof.

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[1] Cantor, vol. iii. p. 568.

[2] Leibnitz, *Works*, vol. v. pp. 340–349.

[3] Cantor, vol. iii. p. 570.

The process of combining two equations by first removing the highest terms, then the lowest, which Maclaurin used in his examples, was systematically described for the first time by Euler (1707–1783) in 1748. Its explanation occupies the first half of the chapter 'De intersectione curvarum' in his 'Introductio in analysin infinitorum.'[3] It also occurs in a memoir presented to the Academy of Sciences in Berlin,[4] where it is preceded by the pertinent remark: 'Dans la plupart des cas si l'on se sert des méthodes ordinaires d'éliminer, on parviendra à une équation de plus de dimensions que mn.' It is then followed by a discussion of a case in which the number of intersections must fall short of mn: when the equation of a curve of order m, namely, is of the form $Py^3 + Qy^2 + Ry + S = 0$, P, Q, R, and S being of dimensions $m - 3$, $m - 2$, $m - 1$, and m respectively in x, since then 'les équations choisies n'expriment pas généralement les courbes des ordres m et n, mais seulement des espèces de ces ordres.' This is the first appearance of a class of equations which were very fully discussed later by Bézout.

Two new methods of elimination were put forward by Euler in these publications; but neither is rigorously demonstrated, and the unsystematic notation once more proves an obstacle to progress. That of the 'Introductio' is the same as had occurred to Leibnitz, but of which he had written nothing for publication. It consists[5] in multiplying each equation by a function of y whose coefficients are undetermined quantities, and then equating to zero the coefficients of the different powers of y in the equation formed by subtracting these equations from each other. From this set of linear equations the undetermined coefficients are eliminated and the resultant obtained. The general rule, however, given for the elimination of the undetermined coefficients is very laborious and far inferior to that which Leibnitz had discovered. This method has taken its place in modern text-books as 'Euler's method,' or, sometimes, as 'Euler's second method':[6] it is really founded on the necessary existence of at least one common root of the two equations if they are to hold simultaneously, and Euler himself explains this in a memoir[7] published sixteen years later (which, however, throws no fresh light on the subject). The same principle is fundamental in the other new method, sketched in the Berlin memoir of 1748. But with this difference. By the one method the common linear factor, corresponding to the common root, was eliminated between the two equations, and from the resulting identity the system of linear equations which led to the resultant were obtained. In the other method the resultant is formed of the products of all possible differences of the roots of the two equations, such as $(a-\alpha)$, if $a, b, c \ldots \alpha, \beta, \gamma \ldots$ are the roots—one of which must certainly vanish—and the crux of the solution lies in the expression of this product in terms of the coefficients of the two equations. Since each equation may also be expressed as a product of factors such as $(x-a)$, the resultant equation is found to be the product of the equations formed from one equation by substituting in it for x the roots of the other equation. And this leads at once to the consideration of certain symmetric functions of the roots, and to the necessity of evaluating them in terms of the coefficients. This process is only sketched by Euler,[1] and thus his proof that the resultant, when the coefficients contain a second variable, attains the degree mn (m and n being the degrees of the equations) in this variable is not conclusive, although the first step, of proving that it is of the mth degree in the coefficients of the equation of the nth degree and of the nth degree in the coefficients of the equation of the mth degree, is correctly taken. This method is sometimes known as 'Euler's first method,'[2] or, more properly, as 'elimination by symmetric functions.' It was also employed with far greater success by Cramer (1704–1752) in the Appendix II. to his 'Introduction à l'analyse des lignes courbes algébriques.'[3] In fact, it is from Cramer's work that the impulse to investigate all possible symmetric functions of the roots of an equation dates. Up till this time the only ones discussed were the products taken one, two, three . . . at a time, known as early as 1629 by Girard[4] to be equal to the successive coefficients of the equations, and the sums of the powers of the roots which Newton had investigated.[5]

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[1] *Usages de l'analyse de Descartes pour découvrir sans le secours du Calcul Différentiel les Propriétés ou Affections principales des Lignes Géométriques de tous Ordres.* *Cf.* Brill and Noether, *loc. cit.*, p. 134.

[2] P. 60.

[3] See Cantor, vol. iii. p. 576, for an account of this work.

[4] 'Démonstration sur le nombre des points où deux lignes des ordres quelconques peuvent se couper,' *Acad. Berlin*, année 1748, pp. 234–248.

[5] See Cantor, vol. iii. p. 577, for detailed description.

[6] *Encyk. der Math. Wissen.*, Leipzig, 1899, Bd. I., p. 246, note 80.

[7] 'Nouvelle méthode d'éliminer les quantités inconnues des équations,' *Acad. Berlin*, année 1764, pp. 91–104.

To Cramer, also, belongs the credit of devising a suitable notation.[6] It is in all essentials the same as Leibnitz's, but was probably invented independently.[7] He writes the two equations from which x is to be eliminated thus:

$$\begin{array}{ll} \text{A} \ldots & x^n-[1]x^{n-1}+[1^2]x^{n-2}-[1^3]x^{n-3}+ \qquad \ldots [1^n]=0 \\ \text{B} \ldots & (0)+(1)x+(2)x^2+(3)x^3+ \qquad \ldots +(m)x^m=0 \end{array}$$

where $[1], [1^2], [1^3], \ldots [1^n]$ are functions of y of degree, 1, 2, . . . n; and $(0), (1), (2), \ldots (m)$ are functions of y of degree $m, m-1, m-2, \ldots 0$; and calls the resulting equation in y, C. C is, then, the product of the equations formed from B by successive substitutions for x of the roots a, b, c, &c., of A; each term of it therefore consists of two factors: 'l'un, facteur-premier, est le produit de quelques coefficients de B; l'autre, facteur-second, est une fonction des racines $a, b, c \ldots$ de l'équation A.'[8] The 'facteurs-premiers' are easily found by combining n at a time the terms

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[1] *Acad. Berlin*, année 1748, p. 245.

[2] *Encyk. der Math. Wissen.*, Leipzig, 1899, Bd. I., p. 245.

[3] *Geneva*, 1750, pp. 660.

[4] Cantor, vol. ii. p. 718.

[5] *Arithmetica Universalis*, 1st edition, p. 251.

[6] *Analyse*, App. I., p. 657.

[7] *Cf.* Cantor, vol. iii. p. 586.

[8] *Loc. cit.*, p. 660.

(0), (1), &c.; they are written, *e.g.*, $(0^{n-1}1)$, $(0^{n-6}111224)$. The 'facteurs-seconds' are connected with the 'facteurs-premiers' by the following perfectly definite statement, in which is seen the importance of the numerical notation: 'Chaque chiffre du facteur-premier annonce, dans le facteur-second qui lui est joint, une puissance des lettres a, b, c, &c., dont ce chiffre est l'exposant, et ces puissances sont autant de termes qu'il y a de manière de les arranger.'[1] In other words, each 'facteur-second' is a symmetric function of the roots $a, b, c, \ldots$ of dimensions equal to the sum of the numbers contained in its bracket. 'Si donc les racines de l'équation A étaient connues, il serait aisé d'avoir tous les facteurs-seconds de l'équation C. Mais ces racines sont inconnues, lorsque l'équation A est d'un degré trop élevé pour que l'algèbre en puisse donner la solution. Cependant ces facteurs-seconds se peuvent toujours calculer et exhiber sous une forme rationnelle, au moyen des coefficients de l'équation A.'[2] And then from the known connection between the coefficients of an equation and the products of the roots taken one, two, . . . together. Cramer, by a somewhat intricate rule, deduced the values of all the symmetric functions required for the determinations of equation C.

The essential feature of this rule is an arrangement of the 'facteurs-premiers' in lines according to a certain law: the first line,[3] for example, being of the type (0000), (0001), (0011), (0111), (1111), the second and third lines are (0002), (0012), (0112), (1112); (0003), (0013), (0113), (1113), and so on. The 'facteurs-seconds' corresponding to the first line are easily seen to be these said sums of the products of the roots taken one, two, three, four together, and are thus equal to 1, $[1]$, $[1^2]$, $[1^3]$, $[1^4]$. All the 'facteurs-seconds' corresponding to the succeeding lines are then shown to be derivable, by means of a multiplication theorem for pairs of 'facteurs-seconds,' from 'facteurs-seconds' corresponding to terms in lines above them, and thus, finally, from the first line; they can therefore be expressed rationally in terms of the coefficients of A. A typical example of the multiplication theorem is:[4]

$$\begin{aligned}(0^{n-6}111223)\times(0^{n-1}1)=&(0^{n-6}111224)+2(0^{n-6}111233)\\&+3(0^{n-6}112223)+4(0^{n-7}1111223)\end{aligned}$$

where, as Cramer is careful to point out, the sum of the significant figures in each bracket of the result is the same, being equal to the sum of those in the two factors. The proof of the theorem lies in translating the symbols into the actual terms for which they stand, viz., using the modern Σ notation,

$$\Sigma abcd^2e^2f^3\times\Sigma a=\Sigma abcd^2e^2f^4+2\Sigma abcd^2e^3f^3+3\Sigma abc^2d^2e^2f^3+4\Sigma abcde^2f^2g^3$$

as is sufficiently evident. A formal proof could, of course, easily be obtained by induction. When the coefficients of equation A are, as we have already assumed them to be, functions of y, the above characteristic of the multiplication theorem enables Cramer to prove that the degree in y of the equation C cannot exceed mn. For each 'facteur-premier' is easily seen to contain y to a power (mn—sum of its numbers), and it only remains to show that the corresponding 'facteur-second,' when evaluated in terms of the coefficient of A, will contain y to a power equal to the sum of the numbers in its bracket.

Now this is seen to be true of the 'facteurs-seconds' corresponding to the first line of 'facteurs-premiers' by reason of their known values. And since each 'facteur-second' can be ultimately reduced, by means of the multiplication theorem, to the sum of products of those in the first line—the total sum of the significant figures in every such product being equal to that in the original bracket—it follows that this sum will be, as required, the power of y. The characteristic property of the multiplication theorem, although only stated with regard to the *roots* of the equation, justifies the conclusion[1] that Cramer had conceived the idea of 'weight' as applied to the expression in terms of the coefficients of a symmetric function of the roots, for the sum of the significant figures in the bracket of a 'facteur-second' (which primarily denotes the degree in the roots) is shown in the proof we have sketched to persist throughout the process of tracing it back to the first line and to be thus equal to the sum of the suffixes in the equivalent expression in terms of the coefficients.

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[1] *Loc. cit.*, p. 664. [2] *Loc. cit.*, p. 665. [3] *Loc. cit.*, p. 663. [4] *Loc. cit.*, p. 668.

§ 8. MEMOIRS ON THE INTERSECTIONS OF PLANE CURVES, FROM MACLAURIN TO LAMÉ, 1720–1818.

The progress of analytical geometry as a whole during this period of about a hundred years is mainly along the lines which Newton had begun to explore. The classic treatises of Euler and Cramer fall within its limits, but, original and fruitful as these works were, they formed rather the climax of the purely Cartesian epoch than the beginning of the modern era. And it is noteworthy, as corroboration of this fact, that both were published before the year 1758, which saw the foundation of the Turin Academy under Lagrange, the 'father of modern mathematics.' The classification of curves according to the degree of their equations, the investigation of all possible types of the same order, of the infinite branches and of the singularities of a given curve, such were the chief problems which occupied these geometers. The notation employed is invariably the Cartesian equation written at full length; the point was thus the primary element in the plane, and the properties of curves were studied as belonging to configurations of points. The number of intersections of a pair of curves and the possibility of passing a curve of given order through a certain number of given points are questions which really belong to a domain beyond the vision of the mathematicians of the eighteenth century—a domain in which a curve itself is the primary element and systems of curves the subject-matter of investigation. They arose, however, naturally enough, the moment the significance of the coefficients in the equation of a curve was recognised, and were only partially answered by Maclaurin, Euler, and Cramer before Lamé, in 1818, took a more important step in their elucidation than he himself probably realised.

The enunciation of the paradox connected with these questions is due to Maclaurin.[2] It forms the second corollary to the Lemma of Section V. in his 'Geometrica Organica,' and may be rendered as follows: 'A line of order n can cut another of the same order in n^2 points. Hence two lines of order n may sometimes pass through the same n^2 points; and thus given points whose number is $\frac{1}{2}n(n+3)$ do not suffice to determine a line of order n in such a way that the curve which can be drawn through them is unique; yet, in truth, since the coefficients in the general equations of a line of order n are $\frac{1}{2}n(n+3)$ in number, it is clear that, if more points are given, it is perhaps not possible to draw a line of order n through them, and the problem may be impossible. So nine points do not as fully determine a line of order three as five do a line of order two; yet ten are too many for the determination of a line of order three.' Shortly expressed, this amounts to the enigmatic statement that $\frac{1}{2}n(n+3)$ points both do and do not determine a curve of order n uniquely. Maclaurin makes no attempt at an explanation, and thirty years elapsed before the matter was again put forward in print. It then appeared simultaneously in two publications—in Cramer's 'Analyse' and in a memoir by Euler entitled 'Sur une contradiction apparente dans la doctrine des lignes courbes.'[1]

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[1] Brill and Noether, *Jahresber. d. deutschen Math. Ver.*, vol. iii. (1894), p. 137. *Cf.* Cantor, vol. iii. p. 588. The reference given by the former to §§ 9, 10 of Cramer's Appendix II. is somewhat misleading, as these only deal with the degree in the roots; but if the whole proof is studied their conclusion is fully established.

[2] See § 6.

Cramer had spent part of a two years' leave of absence from his Geneva professorship in England, and it is perhaps due to this that he alone of foreign mathematicians gives the reference to Maclaurin's corollary in a footnote to his own statement of the paradox:[2] 'Une contradiction apparente . . . est celle-ci. Puisqu'une ligne de l'ordre m ne peut rencontrer une ligne de l'ordre n qu'en mn points, une ligne de l'ordre v ne rencontrera une autre ligne de même ordre qu'en v^2 points. Si donc v^2 est égal ou plus grand que le nombre $\frac{1}{2}v(v+3)$, qui est celui des points qui déterminent une ligne de l'ordre v, on pourra faire passer plus d'une ligne de l'ordre v par $\frac{1}{2}v(v+3)$ points, ce qui semble contraire à l'article § 38.' The explanation he offers is as follows: 'Cette contradiction se lève par la remarque qui termine § 38, c'est qu'encore qu'on ait autant d'équations qu'il en faut, généralement parlant, pour déterminer tous les coefficients de l'équation prise pour représenter la courbe qui doit passer par un certain nombre de points donnés, il peut pourtant arriver que ces coefficients restent indéterminés. Alors l'équation prise reste indéterminé et représente une infinité de courbes du même ordre.' His use of the plural, 'ces coefficients,' is worth noting; in § 38 it is even more emphatic: 'quelques-uns de ces coefficients'; he probably did not recognise that a single infinity only of curves is involved.[3]

Singularly enough, Cramer, in enunciating the paradox, makes no mention of Euler, whose paper had been communicated to the Berlin Academy two years previously and printed in the year of publication of the 'Analyse.' The same volume of the 'Mémoires de l'Académie de Berlin' contains an historical paper by Cramer himself, and it is rather improbable that he had no knowledge of Euler's work.[4] Euler's paper is written with characteristic naïveté, almost suggesting that he is writing down his own train of thought step by step, in meditating over the knotty point. By means of the simplest examples he illustrates the cause of a possible indetermination in one or more of n unknown quantities, connected by n equations, summing up thus: 'Une des quantités inconnues restera indéterminée si une des équations proposées est renfermée dans les autres. De plus, deux ou plusieurs quantités inconnues resteront indéterminées s'il y a parmi les équations deux ou plusieurs, qui sont déjà dans les autres, et qui par conséquent ne contribuent rien à la détermination renfermées des inconnues.'[1] This indicates more insight into the possibilities in the nature of a system of equations than any passage in Cramer; but when he proceeds to make use of this conclusion he fails to bring out the complete resolution of the paradox. He first considers the cases of a straight line and of a conic and shows how they may remain indeterminate, even after assignation of two and five points respectively on them. These cases present no difficulty, but are not really relevant to the paradox, since in their case v^2 is less than $\frac{1}{2}v(v+3)$: they arise when the two assigned points coincide, and when of the five points four lie on a straight line. The cubic, which is the next curve he considers, and to which the paradox is applicable, is confessedly beyond his grasp: 'Il est cependant fort difficile de définir ces cas généralement, comme j'ai fait pour les lignes du second ordre, puisque le calcul, à cause du grand nombre des points et des coefficients, deviendrait trop compliqué. Néanmoins il n'est pas difficile de découvrir plusieurs cas particuliers, où ce defaut dans la détermination a lieu; desquels on ne conclura pas difficilement, que le nombre de tels cas peut être infiniment grand, ce qui suffit pour mon dessein.'[2] The particular cases alluded to are, first, when the nine points are so situated that the cubic through them must degenerate into a conic and a straight line: this is analogous to the case of the conic; and, next, when they are arranged in the shape of a square, so that the equation of a cubic through them is $my(y^2-a^2)=nx(x^2-a^2)$, 'où le rapport des coefficients m et n peut être quelconque, de sorte qu'une infinité de lignes du troisième ordre peut être indiquée, qui passent toutes par ces points donnés.'[3]

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[1] *Acad. Berlin*, année 1748, pp. 219–233.

[2] *Analyse*, pp. 78, 79.

[3] *Cf.* Scott, *Bull. Am. Math. Soc.*, vol. iv. (1898), p. 262.

[4] *Cf.* Cantor, vol. iii. p. 797, where doubt is thrown on Cramer's statement that his *Analyse* was written quite independently of Euler's *Introductio*.

In view of the fact that Euler brings forward this example definitely as a special case, and that he does not even hint at a similar one in the discussion of quartics and quintics with which his paper closes, it is hardly likely that he recognised the universal application of the principle which underlies it; in fact, he actually deduces the equations of the two independent component cubics (each consisting of three straight lines) from the original equations by writing $m=0$, $n=0$, in succession. The principle itself was not formulated until more than sixty years had passed, by Lamé (1795–1870), so slowly do ideas grow. And, precisely as the theory of curves was originally explored in the interests of algebra before the reverse process set in, so here, the intersections of curves were studied with a view to the determination of the curves on which they lie long before the properties of the systems of curves themselves were investigated.

In the preface to his 'Examen des différentes méthodes employées pour resoudre les problèmes de géométrie,'[4] Lamé acknowledges that the general reflections on pure mathematics which occupy a quarter of his book were suggested to him by the problems which it contains; this fact, characteristic of the practical engineer, does not detract from the theoretical importance of the general statement here made for the first time,[5] viz., that an equation whose left-hand side is formed by the additive combination of the left-hand sides of two or three given equations of the same degree, each multiplied by an undetermined quantity, is the adequate representation of all geometrical loci of this degree which pass through the intersections of the lines or surfaces represented by the original equations. It is evident, however, from the examples, that Lamé is really concerned with actually obtaining the necessary conditions in order that three or four given equations may hold simultaneously, and that the singly infinite (and linear) nature of the system in the one case and the doubly infinite (and linear) nature of the system in the other are not of primary importance to him.

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[1] *Loc. cit.*, p. 227.
[2] *Loc. cit.*, p. 231.
[3] *Loc. cit.*, p. 231.
[4] Paris, 1818, pp. 124.
[5] *Loc. cit.*, p. 28.

Meteorological Observations on Ben Nevis.—Report of the Committee, consisting of Lord M'LAREN, Professor A. CRUM BROWN (*Secretary*), Sir JOHN MURRAY, Professor COPELAND, *and* Dr. ALEXANDER BUCHAN. (*Drawn up by* Dr. BUCHAN.)

THE Committee were appointed for the purpose of co-operating with the Scottish Meteorological Society in making meteorological observations at the two Ben Nevis Observatories.

The hourly eye-observations made at the top of the mountain by night as well as by day have been regularly made by Mr. Angus Rankin, the superintendent, and staff of assistants. As the observatory at Fort William is one of the observatories of the Meteorological Council, the observations there are taken from the photographic curves.

The health of the observers has been good during the year. The directors desire to express their very cordial thanks to Messrs. A. Watt, M.A., T. Affleck, R. Aitken, William S. Bruce, and G. Philip for the invaluable services rendered by them as volunteer observers at certain seasons of the year, particularly during the summer months, thus securing to the members of the staff of both observatories the rest they needed from their arduous work; and to Messrs. Wedderburn and Aiken for the valuable observations they have made this summer at the half-way station on the Ben.

The principal results of the observations made at the two observatories during 1900 are detailed in Table I.

TABLE I.

1901	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Pressure in Inches.													
Ben Nevis Observatory	25·230	25·399	25·133	25·162	25·578	25·431	25·559	25·440	25·334	25·249	25·470	24·912	25·325
Fort William	29·874	30·078	29·755	29·722	30·108	29·964	30·022	29·934	29·827	29·801	30·090	29·490	29·889
Differences .	4·644	4·679	4·622	4·560	4·530	4·533	4·463	4·494	4·493	4·552	4·620	4·578	4·564
Mean Temperatures.													
Ben Nevis Observatory	24°·0	22°·0	23°·3	28°·5	38°·3	36°·9	47°·8	40°·7	39°·0	30°·9	28°·4	23°·2	31°·9
Fort William	40·2	36·7	39·6	45·2	52·9	53·9	61·2	56·5	55·8	46·5	41·8	37·1	47·3
Differences .	16·2	14·7	16·3	16·7	14·6	17·0	13·4	15·8	16·8	15·6	13·4	13·9	15·4
Extremes of Temperature, Maxima.													
Ben Nevis Observatory	36·1	31·3	41·2	44·0	52·0	57·1	63·0	56·0	49·0	44·4	39·0	37·5	63·0
Fort William	53·2	48·0	53·3	69·9	72·0	74·6	79·6	69·5	69·2	62·1	55·3	53·0	79·6
Differences .	17·1	16·7	12·1	25·9	20·0	17·5	16·6	13·5	20·2	17·7	16·3	15·5	25·9
Extremes of Temperature, Minima.													
Ben Nevis Observatory	9·1	8·5	6·3	14·3	22·3	24·8	33·9	28·3	28·3	21·3	13·6	12·3	6·3
Fort William	26·3	20·2	15·2	28·2	31·5	38·3	47·0	40·1	36·1	30·4	20·9	18·2	15·2
Differences	17·2	11·7	8·9	13·9	9·2	13·5	13·1	11·8	7·8	9·1	7·3	5·9	—

TABLE I.—*continued.*

1901	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Rainfall, in Inches.													
Ben Nevis Observatory	20·12	5·91	14·95	12·87	4·74	13·19	4·54	12·93	10·65	16·01	15·09	26·13	156·48
Fort William	7·86	2·09	4·22	5·62	1·44	5·97	3·13	5·62	6·64	9·55	4·64	10·68	67·46
Differences	13·14	3·87	11·06	7·49	3·33	7·34	1·35	7·62	4·05	6·87	10·46	15·45	92·03
Number of Days 1 in. or more fell.													
Ben Nevis Observatory	9	1	4	6	1	4	1	5	3	4	4	12	54
Fort William	1	0	1	0	0	1	0	1	2	1	1	2	10
Differences	8	1	3	6	1	3	1	4	1	3	3	10	44
Number of Days 0·01 in. or more fell.													
Ben Nevis Observatory	27	15	18	19	14	24	21	25	18	27	23	28	259
Fort William	22	19	15	19	12	18	16	23	18	25	21	27	235
Differences	5	+4	3	0	2	6	5	2	0	2	2	1	24
Mean Rainband (scale 0–8).													
Ben Nevis Observatory	2·4	1·7	1·1	2·7	1·8	2·8	3·2	2·6	2·5	1·8	1·6	1·9	2·2
Fort William	3·4	2·9	2·9	3·4	3·5	4·0	3·6	4·3	4·3	3·8	3·3	3·7	3·6
Differences	—	—	—	—	—	—	—	—	—	—	—	—	—
Number of Hours of Bright Sunshine.													
Ben Nevis Observatory	14	52	87	102	239	75	124	59	67	15	44	16	894
Fort William	14	49	113	136	248	159	139	114	114	59	40	12	1,197
Differences	0	+3	26	34	9	84	15	55	47	44	+4	+4	303
Mean Hourly Velocity of Wind, in Miles.													
Ben Nevis Observatory	18	9	21	22	11	10	10	15	21	18	13	15	15
Percentage of Cloud													
Ben Nevis Observatory	91	80	75	79	56	86	77	90	86	89	80	89	81
Fort William	80	70	65	64	52	76	80	78	68	76	72	76	71
Differences	11	10	10	15	4	10	+3	12	18	13	8	13	10

This table shows for 1901 the mean monthly and extreme temperature and pressure; the amounts of rainfall, the number of days of rainfall, and of days on which it equalled or exceeded an inch; the hours of sunshine; the mean rainband; and the mean velocity in miles per hour of the wind at the top of the mountain. The mean barometric pressures at Fort William are reduced to 32° and sea level, but those at Ben Nevis Observatory to 32° only.

At Fort William the mean atmospheric pressure was 29·889 inches, or 0·032 inch above the average. The mean at the top was 25·325 inches, or 0·020 inch above the average. The mean difference for the two observatories was 4·564 inches. At the top the absolutely highest pressure for the year was 26·037 inches in May, this being the highest hitherto recorded in May, and the lowest 24·159 inches in December. We may note that in 8 years out of 18 the Ben Nevis barometer has not given a reading below 24 inches. At Fort William the absolutely highest pressure was 30·552 inches in November, and the lowest 28·549 inches in December. The differences of the extremes at top and bottom were therefore 1·878 inch and 2·003 inches respectively.

The deviations of the mean temperatures of the months from their respective averages are shown in Table II. :—

TABLE II.

	Fort William.	Top of Ben Nevis.		Fort William.	Top of Ben Nevis
January	+1°·1	−0°·1	July	+3°·9	+6°·4
February	−2·4	−1·8	August	−0·6	0·0
March	−0·8	−0·6	September	+2·5	+1·0
April	+0·3	+0·7	October	−1·1	−0·4
May	+3·0	+5·0	November	−0·2	+0·5
June	−1·9	−2·8	December	−2·9	−2·0

At both observatories February was the coldest month of the year. In this month northerly winds were seven days in excess of the average prevalence, and winds from south and south-west correspondingly defective. May and July were both exceptionally warm months, the general type of weather being eminently anticyclonic, with a very large excess of sunshine. The absolutely highest temperature for the year at Fort William was 79°·6 on July 20, and at the top 63°·0 on July 3, and the lowest at Fort William 15°·2 on March 29, and at the top 6°·3 on March 25.

In Table III. are given for each month the lowest observed hygrometric readings at the top of Ben Nevis:—

TABLE III.

1901	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Dry Bulb	20°·5	24°·0	27°·9	30°·0	40°·3	53°·0	48°·9	53°·0	33°·1	28°·0	32°·0	21°·3
Wet Bulb	17·1	19·0	19·6	23·1	29·6	39·3	35·1	37·2	28·2	23·9	27·5	16·7
Dew-point	−6·7	−10·5	−14·4	1·4	15·7	26·6	19·9	21·4	18·4	7·1	17·1	−15·6
Elastic Force	·031	·026	·022	·047	·089	·139	·107	·115	·100	·060	·094	·020
Relative Humidity [Sat. = 100]	28	20	14	28	36	34	31	28	53	39	62	18
Day of Month	10	20	21	17	13	7	6	20	2	29	2	22
Hour of Day	2	7	8	10	5	18	21	18	3	21	8	8

Of these relative humidities the lowest, 14, occurred on March 21, with a dew-point of −14°·4. The lowest dew-point of the year was −15°·6 on December 22, the dry bulb being 21°·3 and the wet bulb 16°·7. A noticeable feature of the table is the unusually high values of the minimum humidities in September and November. In the former month the atmosphere on the top of Ben Nevis was continuously saturated from the evening of the 5th till noon on the 11th, and then almost continuously until the 14th. From the 17th to 29th inclusive there were only a few scattered hours at which the humidity was not 100. In November, the 8th to 14th and 17th to 30th were periods of continuous saturation.

The rainfall for the year at the top was 156·43 inches, being less than the average by 1·27 inch. This rainfall was no less than 53·90 inches below the very heavy amount recorded for 1900. June was a very wet month, the rainfall of 13·19 inches being 5·32 inches above the average and greater than any June rainfall except that of 1892, 14·07 inches. February and July were comparatively dry months, with amounts 5·91 inches and 6·02 inches below their respective averages. The greatest fall recorded in a single day was 4·77 inches on March 5. At Fort William the annual rainfall was 67·46 inches, being 9·88 inches, or 13 per cent., below the average.

At the top of Ben Nevis the number of rainy days was 259, and at Fort William 235. At the top the maximum monthly was 28 days in December, and at Fort William 27 days in the same month. In May there were only 14 rainy days at the top and 12 at Fort William. During the year the number of days on which 1 inch of rain or more fell at the top was 54, whereas at Fort William the number of such days was only 10. The corresponding numbers for 1900 were 69 and 15.

The sunshine recorder on Ben Nevis showed 894 hours out of a possible of 4,473 hours, or 20 per cent. of the possible sunshine. The average of the past 18 years being 756 hours, the sunshine of 1901 was 138 hours above the average. May and July were the two sunniest months with amounts 117 hours and 42 hours above their respective averages. The amount of 75 hours in June was deficient by no fewer than 62 hours. At Fort William the number of hours was 1,197, or 44 hours above the average of 11 years. The amount for May was 86 hours above, and that for June 29 hours below the average.

At the Ben Nevis Observatory the mean percentage of cloud was 81, and at Fort William 71, both fractionally below the average. At the top the cloudiest month was December with 91 per cent. This is a low value for the maximum monthly amount, and we may contrast it with 97 in December and 96 in January in 1900. We may note very low cloud amounts at both top and bottom for May.

Auroras were observed on February 19, 20 ; July 27, 28 ; August 20 ; October 9.

St. Elmo's Fire was seen on January 2, 24, 30 ; July 14 ; October 17, 22 ; December 31.

Zodiacal Light :—Not observed during the year.

Thunder and Lightning :—July 14, 18, 19, 20, 21, 22.

Thunder only :—June 11 ; August 12.

Solar Halos :—June 7, 29 ; July 14 ; September 30.

Lunar Halos :—April 2, 23, 27 ; October 29 ; November 21 ; December 22.

Meteors :—May 13, 16.

During the past year Mr. Ormond's time has been chiefly given to revising and otherwise preparing for publication the 'Meteorology of the Ben Nevis Observations,' Part II., containing the observations for the years 1888, 1889, 1890, 1891, and 1892, and an Appendix containing the results of several papers which have appeared in the publications of the Royal Society of Edinburgh and the Scottish Meteorological Society, as well as papers specially written for this volume. A copy of the volume accompanies this report. This is the first of the three volumes for the printing of which the Royal Societies of London and Edinburgh have each voted 500*l*. The second of these volumes is now in the printer's hands.

Meanwhile other large researches are being carried on in the Society's office on the lines indicated by your Committee in their Report to the British Association at Glasgow last year. Dr. Buchan's time has been almost wholly occupied with a discussion of the hourly observations of pressure, temperature, humidity, sunshine, and rainfall at the two observatories, with their interrelations, particularly with the important bearings of the results on weather changes.

So far as the discussion has gone the chief outcome is this, while the difference of the mean temperatures of the two observatories is nearly

15°·5, the reduction of the two barometers to sea level closely agrees after a further reduction for diurnal and seasonal differences, the final difference being only the small difference of 0·005 inch on an average of the ten years beginning with 1891. But if, on the one hand, the mean temperature differences be 12°·0 or less, the difference of the reduced barometers is much less; and, on the other hand, if the temperature differences be 18°·0 or more, then the difference of the reduced barometers is much greater. In the former case the type of weather has been strongly anticyclonic, but in the latter equally strongly cyclonic.

A vital result which comes out in the course of this discussion is shown in the hourly reduced daily values indicating the transition from the anticyclonic to the cyclonic type of weather to be generally slow, extending over several days, thus prolonging in many cases the time of our prevision of the more marked weather changes. It is contemplated that at least another year's discussion of the important question here raised will be required.

It is scarcely necessary to remark that the result here empirically arrived at is in accordance with the principle laid down by Dalton: 'Air charged with vapour or vaporised air is specifically lighter than when without the vapour; or, in other words, the more vapour any given quantity of atmospheric air has in it, the less is its specific gravity.'[1]

Statistics concerning the Training of Chemists employed in English Chemical Industries.—Report of the Committee, consisting of Professor W. H. PERKIN (*Chairman*), Professor G. G. HENDERSON (*Secretary*), Professor H. E. ARMSTRONG, *and* Mr. G. T. BEILBY.

THE Committee decided that the best method of obtaining the desired statistics concerning the training of the chemists employed in English chemical industries was to send a circular-letter, with a form for reply enclosed, to all those members of the Society of Chemical Industry who, so far as could be judged from the designations given in the list of members, occupy a position as manager or chemist in a works. This method was adopted because the great majority of the chemists engaged in technological work in this country are members of that Society, and because no other means of obtaining the information seemed practicable. The result of the inquiry was that more than half of those addressed sent replies to the circular. It is probable that a considerable proportion of those who did not reply are not engaged in chemical works, and therefore the following statistics may be considered to give a fair idea of the present position.

Information concerning their course of training was received from 502 managers and chemists employed in English chemical industries. Of these, 107, or 21 per cent., are graduates, and 395 have not taken a degree; 111, or 22 per cent., are Fellows or Associates of the Institute of Chemistry.

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[1] Dalton, *Meteorological Observations and Essays*, 2nd ed., Manchester, 1834, p. 100.

The following figures give more detailed information :—

Number of graduates of a British University	59
Number of graduates of both a British and a foreign University .	16
Number of graduates of a foreign University	32[1]
	107
Number of non-graduates trained in a British University or University College	137[2]
Number of non-graduates trained in a British Technical College .	165
Number of non-graduates trained in a foreign University or Technical College	8
Number of non-graduates trained in Evening Classes, analysts' laboratories, works' laboratories, or otherwise	85
	395

The distribution of the chemists among the principal industries is shown in the following table :—

Industry	Graduates			Non-graduates, trained in				Total
	of British University	of British and foreign University	of Foreign University	University or University College	Technical College	Foreign University or Technical College	Evening Classes, &c.	
Acids, Alkalis, Inorganic Salts	9	3	5	20	19	2	20	78
Metallurgical (various)	1	—	4	19	13	—	14	51
Explosives . . .	6	—	1	4	28	1	6	46
Dyeing and Printing .	3	—	—	13	16	—	5	37
Oils, Fats, Soap, Candles	2	1	3	11	9	1	5	32
Colours, Pigments, Oils, Varnishes	8	1	2	6	5	—	6	28
Brewing and Distilling	3	—	4	8	12	—	1	28
Fine Chemicals, Pharmaceuticals, Confections	7	—	—	9	6	—	4	26
Sugar, Starch, Glucose .	3	2	1	2	8	—	3	19
Cement, Tiles, Pottery .	—	1	1	5	10	—	1	18
Aniline Colours . .	2	3	7	2	2	1	—	17
Tar Distilling . .	—	—	—	5	8	—	3	16
Paper, Paper Pulp .	—	—	2	3	3	—	—	8
Glue, Gelatine, Size .	—	1	—	4	2	—	—	7
Paraffin and Paraffin Oil	—	—	—	3	4	—	—	7
Dyewood and Tanning Extracts	—	—	—	5	2	—	—	7
Cyanides and Ferrocyanides	3	1	—	—	2	—	—	6
Glass	2	—	—	2	1	—	1	6
Coal Gas . . .	—	1	—	—	3	—	2	6
Miscellaneous . .	10	2	2	16	12	3	14	59
Total . .	59	16	32	137	165	8	85	502

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[1] Thirteen of whom studied also in a British University or Technical College.

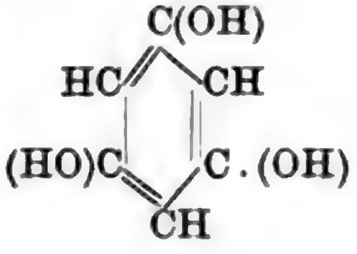
[2] Twenty of whom studied also in a foreign University or Technical College.

Absorption Spectra and Chemical Constitution of Organic Substances.—Fourth Interim Report of the Committee, consisting of Professor W. NOEL HARTLEY (*Chairman and Secretary*), Professor F. R. JAPP, Professor J. J. DOBBIE, *and* Mr. ALEXANDER LAUDER, *appointed to investigate the Relation between the Absorption Spectra and Chemical Constitution of Organic Substances.*

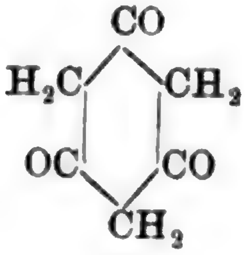
THE Committee has been occupied with two distinct branches of its work, each of which has demanded a large share of attention. First, the spectra and constitution of phloroglucinol and of substances derived therefrom, as being intimately connected with tautomerism. Secondly, the absorption curve of quinone and substances of a like nature, as being connected with the view that quinone has a special structure, and that all organic colouring matters are constructed on the same type.

PART I.—*The Absorption Spectra of Phloroglucinol and some of its Derivatives. By* W. N. HARTLEY, *D.Sc., F.R.S.,* JAMES J. DOBBIE, *D.Sc., M.A., and* ALEXANDER LAUDER, *B.Sc.*[1]

Phloroglucinol reacts with some reagents as a phenol, with others as a ketone. When heated with phenyl-isocyanate in benzene solution it yields a tricarbanilide derivative, $C_6H_3(O{\cdot}CO{\cdot}NH{\cdot}C_6H_5)_3$, and when alkylated under certain conditions it gives derivatives which are regarded as true ethers, since their alkyl groups are split off by heating with hydrogen iodide. On the other hand, it reacts with hydroxylamine with formation of a trioxime, and forms alkylated derivatives, from which the alkyl groups are not split off by boiling with hydrogen iodide. It is impossible, therefore, from its chemical behaviour to decide whether the oxygen atoms of phloroglucinol are present in enolic or ketonic groups; that is to say, whether it possesses the structure (I.) or (II.)—



I.



II.

If it possesses the structure represented by (I.) its absorption spectra should closely resemble the spectra of the trimethyl ether, M.P. 52°, which is decomposed by boiling with hydrogen iodide. If, on the other hand, it possesses the structure represented by (II.), its spectra should resemble those of the alkyl derivatives which are not decomposed under this treatment.

Before comparing the absorption spectra of phloroglucinol and its alkyl derivatives we deemed it advisable to examine specimens of phloroglucinol from as many different sources as possible, and for this purpose specimens were prepared from (1) kino, (2) maclurin, (3) resorcinol, (4) phenol, and

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[1] *Chem. Soc. Trans.*, August 1902.

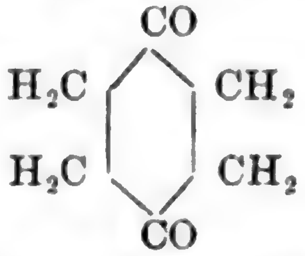
(5) phloroglucinol tricarboxylic ester. As the melting-point of phloroglucinol is variously stated at temperatures ranging from 210–217°, we made a careful comparison of all our pure preparations with the view of determining whether specimens obtained from different sources really differ from one another as regards this property, or whether the differences observed are merely due, as stated by Baeyer,[1] to the various determinations not having been made under the same conditions. We first compared several specimens of phloroglucinol from kino which had been carefully purified by recrystallisation, and found that when slowly heated side by side they melted at 210°, and when quickly heated at 217°. All the other specimens when heated side by side with the specimens from kino behaved in the same way.

The absorption spectra of aqueous solutions of all the five specimens were photographed, and the curves on comparison were found to be practically identical. It may therefore be regarded as definitely established that phloroglucinol from whatever source obtained has always the same structure.

On comparing the spectra of phloroglucinol with those of the trimethyl ether, M.P. 52°, the resemblance between them was found to be so close as to leave no doubt as to the enolic structure of phloroglucinol, assuming that the ether itself possesses this structure.

Furthermore, the resemblance is so close that it is impossible to suppose that the phloroglucinol contains any appreciable quantity of substance with a ketonic structure.[2]

Both phloroglucinol and its trimethyl ether show a selective absorption, the absorption band, however, not being strongly marked. If phloroglucinol possessed the ketonic structure the absorption band would be entirely absent since diketohexamethylene, a substance of similar structure to the ketonic derivatives of phloroglucinol, shows only general absorption.[3]



Diketohexamethylene.

On the other hand, the presence of an absorption band is characteristic of substances having the true benzenoid structure; confirmation of this conclusion is afforded by the great similarity which exists between the spectra of phloroglucinol and those of pyrogallol, a substance which exhibits no ketonic reactions.[4] The spectra of pyrogallol were described by Hartley and Huntington,[5] but as the method of representation employed at that time was different from that now adopted, we have rephotographed the spectra and redrawn the curve to facilitate comparison with phloroglucinol. For the same reason we include in this paper an account of the re-examination of the absorption spectra of phenol.[6]

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[1] *Ber.*, **19**, 2186.
[2] *Chem. Soc. Trans.*, 1899, **75**, 640; 1900, **77**, 839.
[3] *Ibid.*, 1898, **73**, 598.
[4] Baeyer, *Ber.*, **19**, 163.
[5] Hartley and Huntington, *Phil. Trans.*, Part I., 1879, 257.
[6] Hartley and Huntington, *loc. cit.*

We have also rephotographed and remeasured the absorption spectra of quinol, resorcinol, and pyrocatechol, which were described by Hartley in 1888.[1] The agreement between the new and old series of measurements is so close, although taken from photographs of the spectra of different preparations and photographed with different instruments, after an interval of fourteen years, that we have not thought it necessary to repeat an account of them in this paper.

On comparing the mono-, di-, and tri-hydroxy-derivatives it will be observed that while the spectra of the mono- and di-derivatives agree very closely, those of phenol and pyrocatechol being almost identical, the spectra of the tri-hydroxy-derivatives differ from the others in showing less general absorption and in having the absorption band much less distinctly marked.

Experimental Part.

Phloroglucinol.—The specimens of phloroglucinol which we examined were obtained from five different sources.

(1) Specimens prepared from kino were obtained from Merck and from Schuchardt. Both preparations were supplied to us in beautiful scaly crystals, which were practically colourless, and behaved in exactly the same way when heated side by side. They were recrystallised repeatedly from water before being photographed.

(2) Commercial phloroglucinol, prepared by Schuchardt from resorcinol, was purified by the method given by Will[2] and Skraup.[3] The purification was completed by boiling with charcoal and crystallising repeatedly from water. The specimen was then tested for diresorcin by dissolving in concentrated sulphuric acid and heating the solution in the water-bath with acetic anhydride. No violet coloration was produced.[4] All the specimens of commercial phloroglucinol used in the course of this investigation were purified by the above method.

(3) Phloroglucinol was prepared from the tricarboxylic ester by fusion with potassium hydroxide.[5] The specimen obtained by this method crystallised very readily in beautiful plates, which, after being recrystallised several times, had the correct melting-point.

(4) The method given by Barth and Schreder[6] was employed in the preparation of a fourth specimen. Phenol was melted with six times its weight of sodium hydroxide, and heated until the evolution of hydrogen ceased. The fused mass was acidified with dilute sulphuric acid, and the phloroglucinol extracted with ether. The yield of phloroglucinol was small. So far as we could detect, its properties were identical with those of the other specimens which we examined. It melted at the same temperature as the specimens from kino when the determinations were carried out side by side. Its absorption spectra were also identical with those of the specimens from kino. If, as stated by Gautier,[7] an isomer of phloroglucinol is obtained by fusing phenol with soda, it is certain that phloroglucinol is likewise one of the products of the reaction.

(5) A fifth specimen was prepared from maclurin by fusion with potassium hydroxide according to the method described by Hlasiwetz and Pfaundler.[8]

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[1] *Chem. Soc. Trans.*, 1888, **53**, 641.

[2] *Ber.*, **18**, 1323.

[3] *Monatshefte*, **10**, 724.

[4] Herzig and Zeisel, *Monatshefte*, 1890, **11**, 421.

[5] Baeyer, *Ber.*, **18**, 3454.

[6] *Ber.*, 1879, **12**, 417.

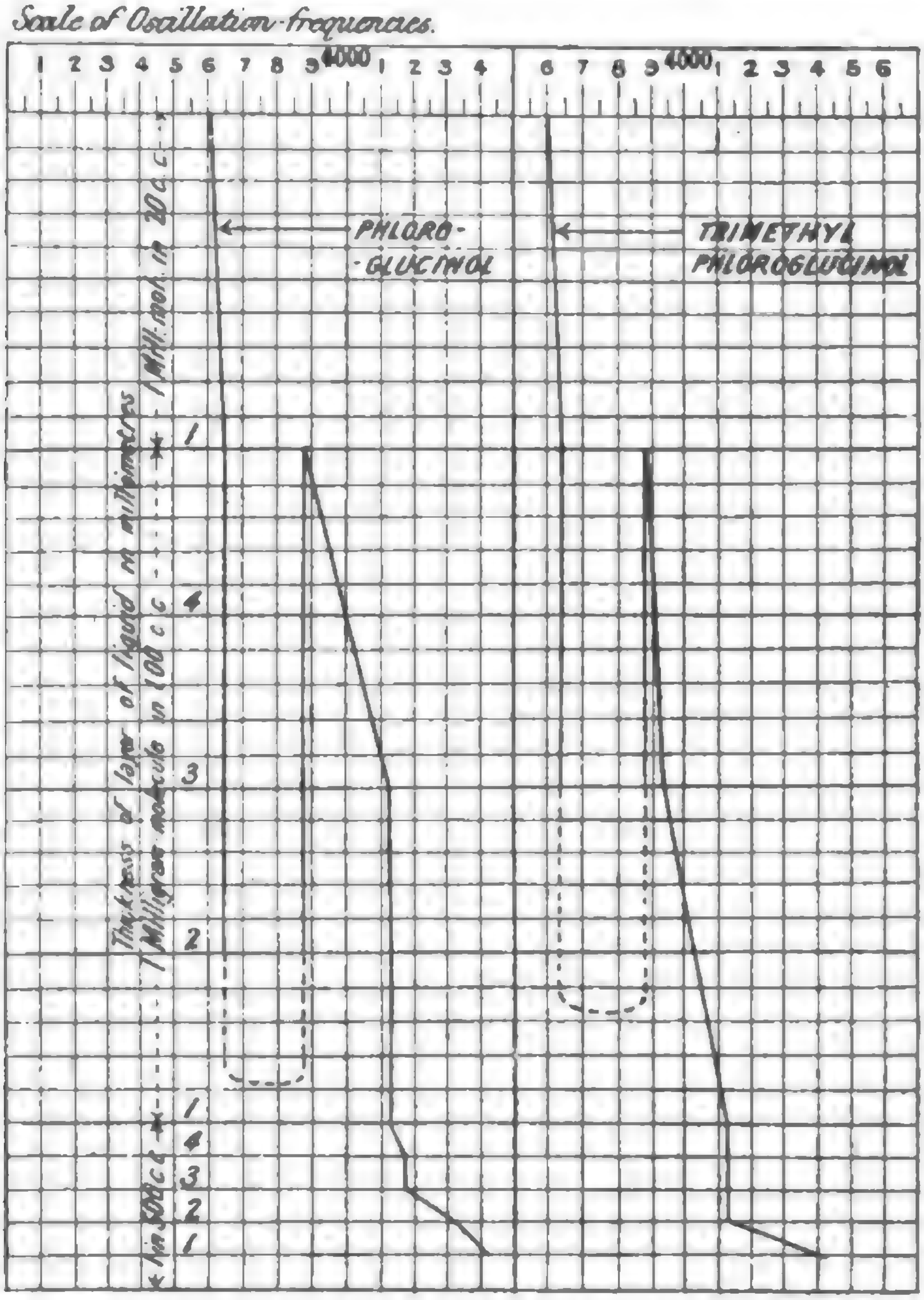
[7] *Bull. Soc. Chim.*, **33**, 585.

[8] *Ann.*, **127**, 351.

The absorption spectra of aqueous solutions of all the specimens of phloroglucinol described above were photographed, and, on comparison, found to be identical. The measurements were actually taken and the curve drawn from the photographs of the specimen prepared from resorcin and purified by Skraup's method.

A layer 50 mm. thick of a solution containing 1 milligram molecule in

Curves of Molecular Vibrations.—(1) Phloroglucinol; (2) Trimethylphloroglucinol.

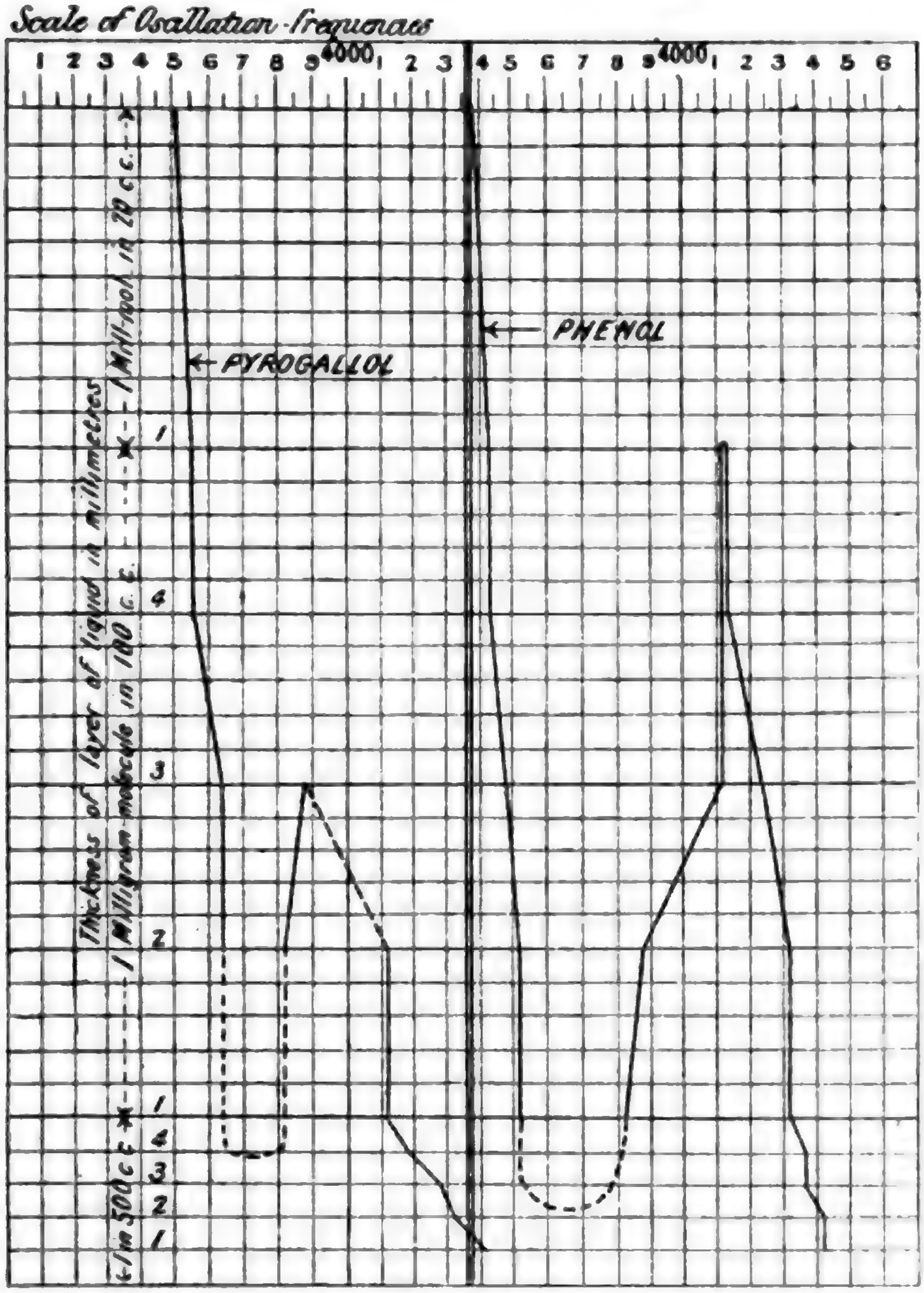


20 c.c water absorbs all rays beyond $^1/\lambda$ 3323 ($\lambda=3009$), while a layer 5 mm. thick of the same solution absorbs all rays beyond $^1/\lambda$ 3568 ($\lambda=2802$).

The absorption band is not strongly marked: it appears first in the layer 1 mm. thick of the solution containing 1 milligram-molecule in 20 c.c. water, and nearly dies out in the layer 2 mm. thick of the solution containing 1 milligram-molecule in 100 c.c., although its position is still distinctly traceable by the weakness of the spectra in solutions of greater dilution. The absorption spectra of phloroglucinol in aqueous and alcoholic solutions are identical.

Phloroglucinol trimethyl ether.—This compound was prepared by saturating a solution of pure phloroglucinol in methyl alcohol with hydro chloric acid gas, and subsequently treating the dimethyl ether so obtained with methyl iodide and potassium hydroxide dissolved in methyl alcohol.[1] The product is an oil which quickly solidifies to beautiful colourless prisms, M.P. 52·5°.

Curves of Molecular Vibrations.—(3) Pyrogallol; (4) Phenol.



The spectra of this substance in alcoholic solution were photographed, and the compound itself was afterwards recovered from the alcoholic solution and found to be unaltered. The spectra are practically identical with those of phloroglucinol, as will be seen from a comparison of the measurements and curves.

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[1] Will, *Ber.*, **21**, 603.

Pyrogallol.—A specimen of pyrogallol obtained from Schuchardt was purified by crystallisation. It melted at 132–134°. It was photographed in aqueous solution, and gave spectra very similar to those of phloroglucinol; the amount of general absorption is slightly greater; the absorption band, which occupies the same position, is somewhat narrower, and dies out at the same degree of dilution as in the case of phloroglucinol.

Phenol.—The specimen employed was prepared from the purest salicylic acid by distillation with lime, B.P. 182°. The salicylic acid, 'physiologically pure,' was kindly presented for the purpose of this investigation by Messrs. Burgoyne, Burbidges, and Co. It has been shown by Hartley [1] that the natural salicylic acid, and that prepared by Klobe's process but purified by recrystallising the calcium salt and separating the acid, are identical in physical and chemical properties.

PHLOROGLUCINOL.

$C_6H_3(OH)_3$ [1 : 3 : 5]. M.P. 210–217°.

Prepared from resorcin and purified by Skraup's method.

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 20 c.c. *water.*		
50 and 25	Spectrum continuous to	3323	3009
20 and 15	,, ,,	3362	2974
10	,, ,,	3521	2840
5, 4, 3, 2	,, ,,	3568	2802
1	,, ,,	3638	2748
	Absorption band	**3638–3886**	**2748–2573**
	Line at	3886	2573
	1 *milligram-molecule in* 100 c.c. *water.*		
5 and 4	Spectrum continuous to	3638	2748
	Absorption band	**3638–3886**	**2748–2573**
	Line at	3886	2573
3	Same as 4, but with very faint indication of spectrum from	3886–4117	2573–2248
2	Spectrum continuous to	3638	2748
	Absorption band	**3638–3886**	**2748–2573**
	Lines showing in absorption band at	3693, 3824	2707, 2615
	Weak spectrum transmitted from	3886–4133	2573–2419
1	Spectrum practically continuous to	4133	2419
	But still weak in the position of the absorption band.		
	1 *milligram-molecule in* 500 c.c. *water.*		
5	Spectrum practically continuous to	4133	2419
	But still weak in the position of the absorption band.		
4 and 3	Spectrum continuous to	4175	2395
2	,, ,,	4320	2314
1	,, ,,	4421	2261

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[1] Hartley, *Chem. Soc. Trans.*, 1888, **53**, 664.

TRIMETHYLPHLOROGLUCINOL.

$C_6H_3(O{\cdot}CH_3)_3$ [1 : 3 : 5]. M.P. 52°.

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 c.c. *alcohol.*		
25	Spectrum continuous to . . .	3534	2829
20, 15, 10	„ „ . . .	3568	2802
5 and 4	„ „ . . .	3638	2748
	Absorption band	**3638–3886**	**2748–2573**
	Line at	3886	2573
3	Spectrum continuous to . . .	3638	2748
	Absorption band	**3638–3886**	**2748–2573**
	Lines showing in absorption band at .	3694	2707
	and	3824	2615
	Very faint indications of spectrum beyond	3886	2573
2	Spectrum practically continuous to .	4038	2476
	Still weak in position of absorption band.		
1	Spectrum continuous to . . .	4133	2419
	1 *milligram-molecule in* 500 c.c. *alcohol.*		
5, 4, 3 and 2	Spectrum continuous to . . .	4133	2419
1	„ „ . . .	4421	2261

PYROGALLOL.

$C_6H_3(OH)_3$ [1 : 2 : 3]. M.P. 132–134°.

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 20 c.c. *water.*		
25	Spectrum continuous to . . .	3386	2954
20 and 15	„ „ „ . . .	3474	2878
10	„ „ „ . . .	3491	2864
5 4, 3, 2	„ „ „ . . .	3521	2840
1	„ „ „ . . .	3568	2802
	1 *milligram-molecule in* 100 c.c. *water.*		
5 and 4	Spectrum continuous to . . .	3568	2802
3	„ „ „ . . .	3638	2748
	Absorption band	**3638–3886**	**2748–2573**
	Line at	3886	2573
2	Spectrum continuous to . . .	3638	2748
	Absorption band	**3638–3824**	**2748–2615**
	Very weak spectrum from . . .	3824–4125	2615–2424
	Line showing in absorption band at .	3694	2707
1	Spectrum practically continuous to .	4125	2424
	But still weak in the position of the absorption band.		

PYROGALLOL—*continued.*

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 500 c.c. *water.*		
5	Spectrum practically continuous to .	4125	2424
	But still weak in the position of the absorption band.		
4	Spectrum continuous to	4165	2400
	But still weak in the position of the absorption band.		
3	Spectrum continuous to . . .	4297	2327
2	„ „ „ . . .	4321	2314
1	„ „ „ . . .	4405	2270

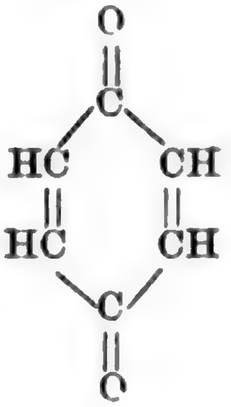
PHENOL.

C_6H_5 (OH). B.P. 182°.

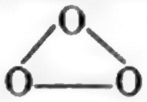
Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 20 c.c. *alcohol.*		
25 and 20	Spectrum continuous to . . .	3179	3145
15	„ „ „ . . .	3179	3145
	Faint prolongation to	3240	3086
10 and 5	Spectrum continuous to . . .	3295	3034
4 and 3	„ „ „ . . .	3323	3009
2	„ „ „ . . .	3354	2981
	1 *milligram-molecule in* 100 c.c. *alcohol.*		
5	Spectrum continuous to . . .	3429	2916
	Lines showing very faintly at . .	4125	2424
	and	4245	2355
4	Spectrum continuous to . . .	3429	2916
	Absorption band	**3429–4112**	**2916–2431**
	Spectrum continuous to . . .	4112–4125	2431–2424
3	„ „ „ . . .	3491	2864
	Absorption band	**3491–4112**	**2864–2431**
	Spectrum continuous from . . .	4112–4245	2431–2355
2	„ „ to . . .	3521	2840
	Absorption band	**3521–3886**	**2840–2573**
	Spectrum continuous from . . .	3886–4321	2573–2314
	1 *milligram-molecule in* 500 c.c. *alcohol.*		
5	Spectrum continuous to . . .	3527	2835
	Absorption band	**3527–3824**	**2835–2615**
	Lines showing in absorption band at .	3568	2802
	and	3638	2748
	Spectrum continuous from . . .	3824–4321	2615–2314
4	„ „ to . . .	3527	2835
	Absorption band	**3527–3824**	**2835–2615**
	Lines showing in absorption band at .	3568	2802
	and	3638	2748
3	Spectrum continuous to . . .	3824–4368	2615–2289
	„ practically continuous to .	4368	2289
	But still very weak in the position of the absorption band.		
2	Spectrum continuous to . . .	4413	2266

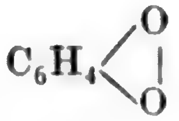
PART II.—*On the Curves of Molecular Vibrations of Quinone,* p-*Nitroso-phenol, and similarly derived Substances.*

The absorption spectra of quinone, *p*-nitroso-phenol (quinonoxime), have recently been investigated by Messrs. Hartley, Dobbie, and Lauder, not only with a view to obtaining information on the subject of the constitution of these substances as represented by the different formulæ which have been proposed for them, but also to determine whether there was any special character in the absorption curves of substances of the quinone type common to and distinctive of all coloured substances and dyes, which could be conceived to be connected with some peculiarity in their structure. There are some features which the three absorption curves of quinone, *p*-nitroso-phenol, and quinone dioxime show in common, and *v*-nitroso-phenol appears to stand in an intermediate position between the other two. It may be the case that in a substance with such a constitution as that represented by the following formula the oxygen is so condensed



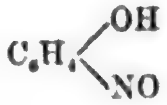
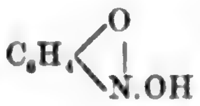
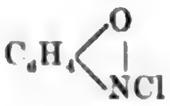
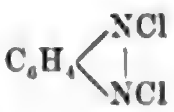
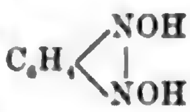
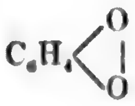
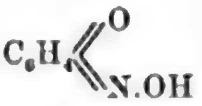
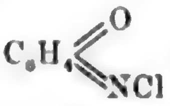
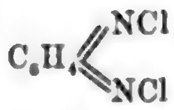
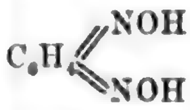
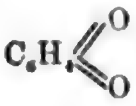
in the molecule that it forms a new kind of ring which possesses special absorption properties resembling a modification of the benzene nucleus, but differing chiefly in the greatly increased intensity of the absorption.

If such a structural constitution is a reality the facts in support of it have yet to be discovered. On the other hand, the formulæ for quinone may very well be written in a manner similar to that of ozone, a substance which gives both a general and a selective absorption of a powerful character, and which possesses a deep blue colour. If one atom of oxygen in ozone  be replaced by the benzene residue C_6H_4 we have quinone as represented according to the peroxide formula



In point of fact the peculiarity of the quinone absorption curve is that it contains two broad absorption bands shown at different stages of dilution, and if we compare the curve of phenol with that of quinone, and also with the absorption spectrum of ozone, we perceive how the atoms of oxygen have modified the spectrum of the phenol. There is this much of similarity between them, that if we can suppose benzene and ozone to be exerting a mutual action on their molecular and intramolecular vibrations, and then form a judgment from what has been observed as to the effect of substitution in the benzene ring in a large number of instances, we can conceive of the change in their combined spectra resulting in a curve not dissimilar from that of quinone, the benzene residue C_6H_4 being united to O_2, as in the preceding formula.

The following alternative formulæ have been proposed for *p*-nitroso-phenol, quinone, and the related substances quinone chlorimide, quinone dichlorimide, and quinone dioxime. The chemical arguments by which these alternate formulæ are supported are sufficiently well known; they are generally regarded as inconclusive.

	p-Nitroso-phenol	Quinone Chlorimide	Quinone Dichlorimide	Quinone Dioxime	Quinone
	a	b	c	d	e
I.		—	—	—	—
II.					
III.					

If the formulæ II. are accepted, the substances have the benzenoid structure; whereas, if the formulæ III. are accepted, they all contain partially reduced benzene nuclei. So far all the substances containing partially or completely reduced nuclei[1] which have been examined differ from those containing unreduced nuclei in giving absorption spectra which show no bands; *i.e.*, they behave like open chain compounds. If this rule is of general application, and if we assume that nitroso-phenol, quinone, &c., are correctly represented by formulæ III., they should show only general absorption. But as a matter of fact the spectra of all the bodies show well-marked absorption bands. Their spectroscopic examination, therefore, favours the peroxide rather than the ketonic theory of their constitution.

On comparing the curves of the various substances with one another, it will be seen that there is a considerable amount of agreement between the curves of quinone dichlorimide and quinone dioxime, and between those of quinone chlorimide and quinone dichlorimide, the differences between them being such as were to be anticipated from the differences in their composition.

The spectra of quinone, on the other hand, differ widely from the others, and it is impossible in the present state of our knowledge of the subject to say whether this difference is due to the difference in composition or to some structural difference. We had hoped, from a comparison of the spectra of quinone chlorimide and *p*-nitroso-phenol, to be able to decide with certainty as to whether the constitution of the latter substance should be represented by the formula I. or II. If it differs only from quinone chlorimide by the substitution of OH for Cl, we should expect at least as close a resemblance between the spectra of the two bodies as between the spectra of quinone dioxime and quinone dichlorimide, seeing that the difference in both cases would consist merely in the substitution of OH for Cl. The difference, however, is considerably greater in the one case than in the other, as will be seen by reference to the diagrams.

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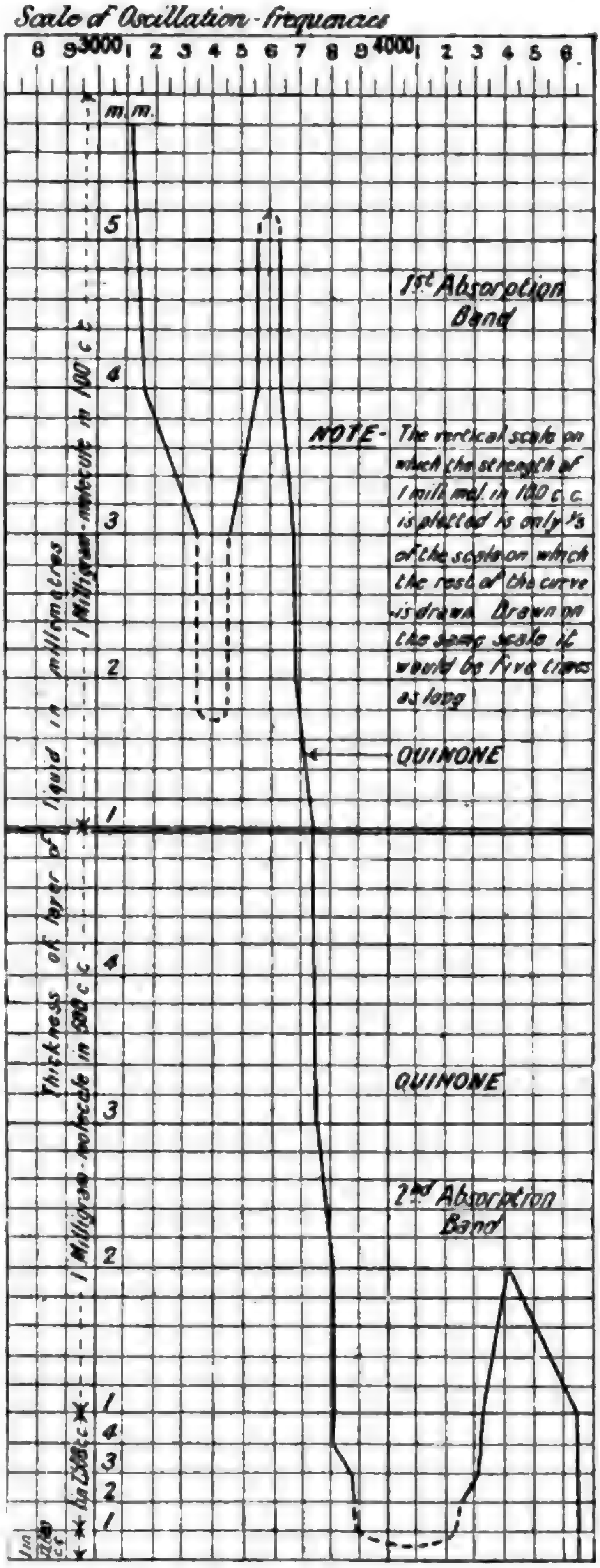
[1] Hartley, *Chem. Soc. Trans.*, 1885, **47**, 685; Hartley and Dobbie, *ibid.*, 1900, **77**, 846.

Curves of Molecular Vibrations.—(5) Quinone



NOTE- The vertical scale on which the strength of 1 milli mol. in 100 c.c. is plotted is only ⅕ of the scale on which the rest of the curve is drawn. Drawn on the same scale it would be five times as long

Though we do not regard the evidence as conclusive, we are of opinion that it does not favour the representation of *p*-nitroso-phenol by a formula analogous to that of quinone chlorimide.

The chemical properties of quinone are as much those of a peroxide as of a ketone; for instance, under the influence of sunlight it oxidises alcohol to aldehyde,[1] while it undergoes reduction to quinol.

In like manner it oxidises isopropyl alcohol to acetone. It acts upon polyhydric aliphatic alcohols, producing sugar-like substances, such as were obtained by E. Fischer by the action of alkaline hypobromites; for instance, from mannitol is obtained mannitose.

Experimental Part.

Quinone.—The specimen of quinone which we examined was prepared in the usual way by the oxidation of aniline. The absorption spectra of its aqueous solution shows two well-marked absorption bands. The first band appears in the layer five millimetres thick of the solution containing one milligram-molecule in 100 c.c. water.

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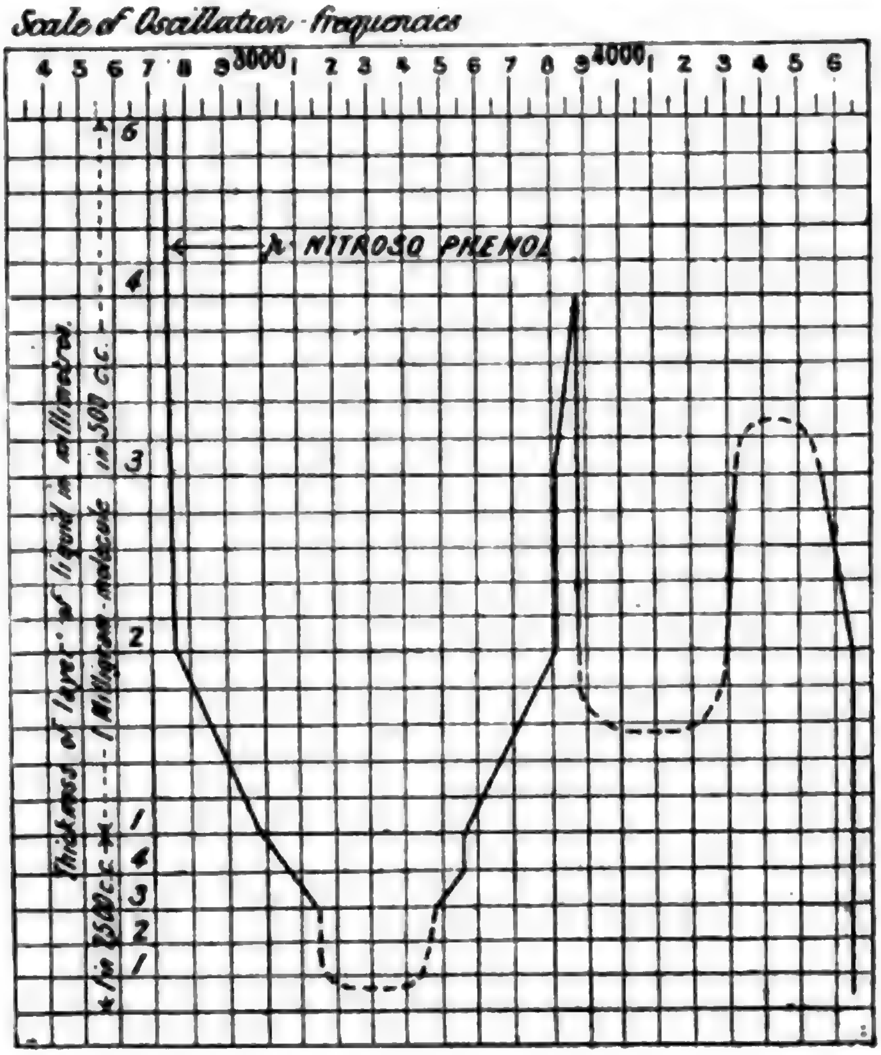
[1] Ciamician and Silber, *Ber.*, 1901, **34**, 1350.

The second band first appears in the layer two millimetres thick of the solution containing one milligram-molecule in 500 c.c. water, and is still distinctly traceable in the layer three millimetres thick of the solution containing one milligram-molecule in 12,500 c.c. water.

p-*Nitroso-phenol.*—This substance was prepared by the action of nitrous acid on phenol. The absorption spectra of alcoholic solutions were photographed. The general absorption is considerably greater than in the case of quinone dichlorimide.

Curves of Molecular Vibrations.—(6) *p*-Nitroso-phenol.



The layer two millimetres thick of the solution containing one milligram-molecule in 100 c.c. absorbs all rays beyond $^1/\lambda$ 2500 ($\lambda = 3996$).

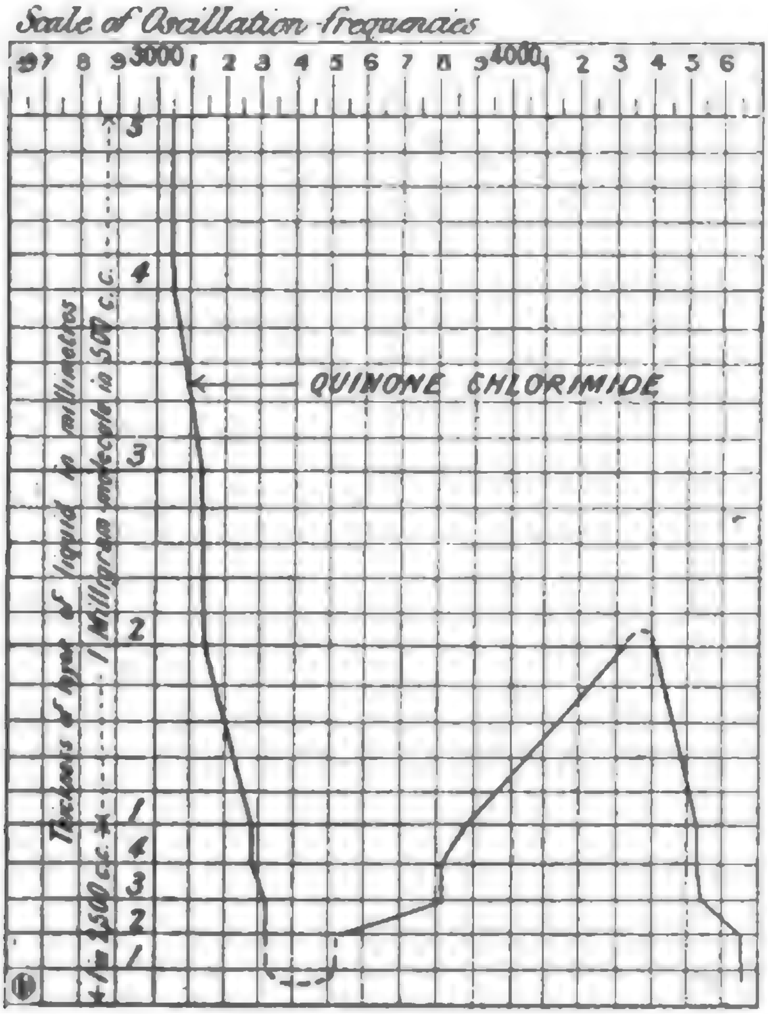
In the layer four millimetres thick of the solution containing one milligram-molecule in 500 c.c. the spectrum is transmitted to $^1/\lambda$ 2714 ($\lambda = 3684$).

At this dilution a wide absorption band begins to appear, which is still traceable in a layer one millimetre thick of a solution containing one milligram-molecule in 2,500 c.c.

A second less persistent absorption band lying between $^1/\lambda$ 3886 (λ = 2573) and $^1/\lambda$ 4321 (λ = 2314), appears in the layer three millimetres thick of the solution containing one milligram-molecule in 500 c.c., and has nearly disappeared in the layer two millimetres thick of the same solution.

Quinone chlorimide.—A specimen of this substance was obtained by reducing *p*-nitro-phenol with tin and hydrochloric acid, and afterwards oxidising the *p*-amido-phenol thus obtained with an aqueous solution of bleaching powder. The golden-yellow crystals melted at 85°. The absorption spectra were photographed in alcoholic solution. The general absorption is considerably less than in the case of nitroso-phenol; a layer two millimetres thick of a solution containing one milligram-molecule in 100 c.c. absorbs all rays beyond $^1/\lambda$ 2884 (λ = 3467).

Curves of Molecular Vibrations.—(7) Quinone Chlorimide.



In the corresponding layer of the solution containing one milligram-molecule in 500 c.c. the spectrum is transmitted to $^1/\lambda$ 3148 (= 3176), beyond which the rays are absorbed up to $^1/\lambda$ 4321 (λ = 2314).

The absorption band, which begins to appear at this dilution, can still be traced in the layer three millimetres thick of the solution containing one milligram-molecule in 12,500 c.c.

Quinone dioxime.—This substance was prepared by the action of hydroxylamine hydrochloride on hydroquinone.

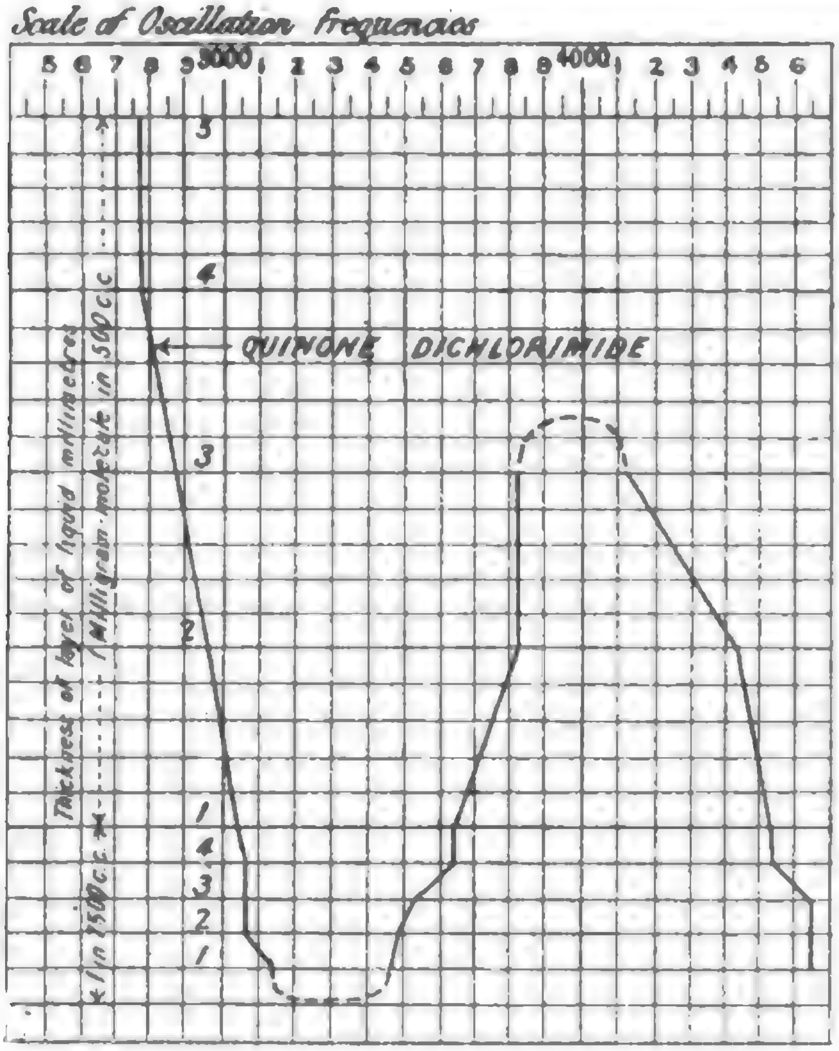
It melted with decomposition at 240°. Its absorption spectra in alcoholic solution were photographed.

A layer two millimetres thick of a solution containing one milligram-molecule in 100 c.c. transmits the spectrum to $^1/\lambda$ 2744 ($\lambda = 3644$), beyond which point there is complete absorption to $^1/\lambda$ 4321 ($\lambda = 2314$).

The absorption band, which begins here, is very well marked and persistent, being still traceable in a layer three millimetres thick of a solution containing one milligram-molecule in 12,500 c.c.

Quinone dichlorimide.—This substance was prepared from the hydrochloride of *p*-phenylene diamine by oxidation with bleaching powder. It decomposed at 124°. Its absorption spectra in alcoholic solution were photographed.

Curves of Molecular Vibrations.—(8) Quinone Dichlorimide.

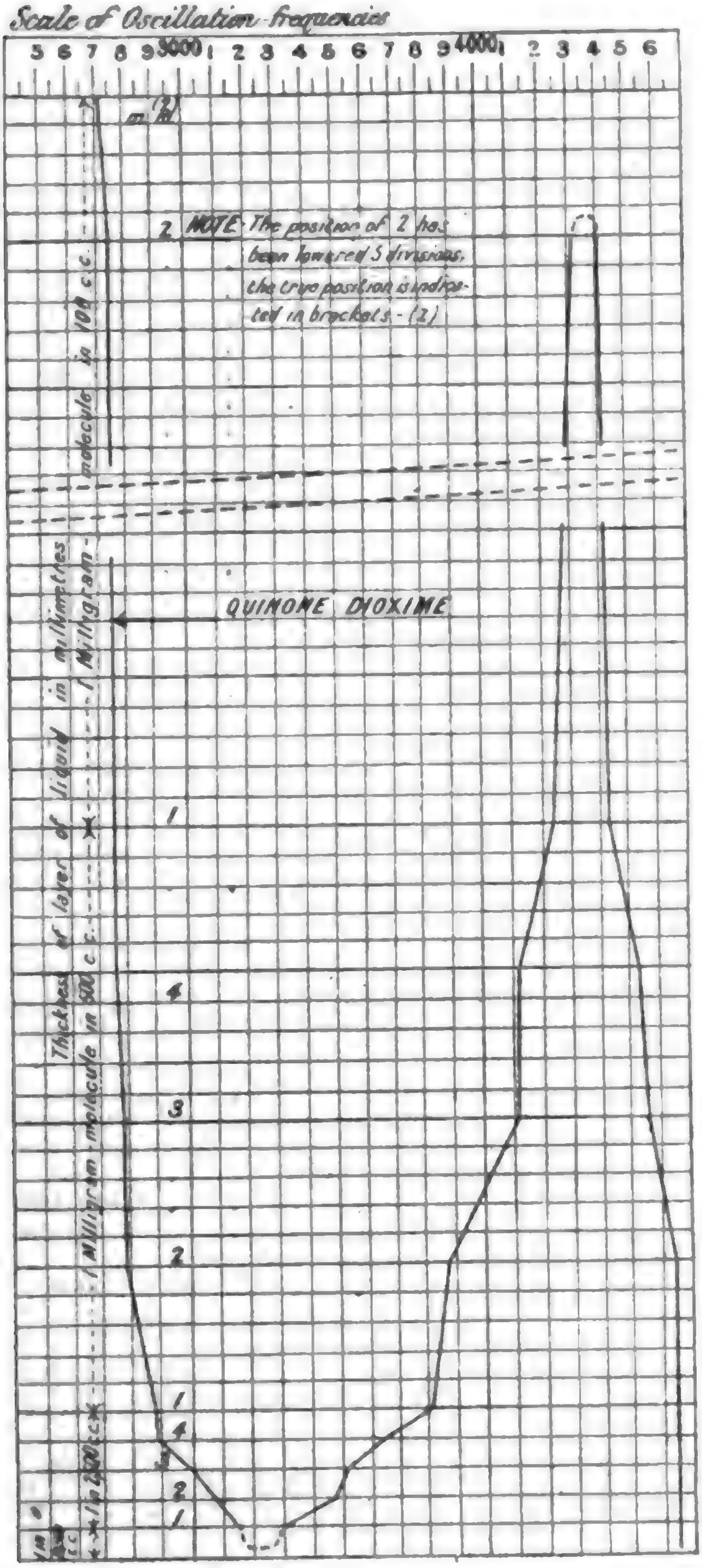


A layer two millimetres thick of the solution containing one milligram-molecule in 100 c.c. alcohol transmits all rays to $^1/\lambda$ 2768 ($\lambda = 3612$).

The absorption band first makes its appearance in the layer three millimetres thick of the solution containing one milligram-molecule in 500 c.c., and can still be traced in the layer three millimetres thick of the solution containing one milligram-molecule in 12,500 c.c.

The amount of general absorption is very nearly the same as in the case of quinone dioxime, but the absorption band does not make its appearance so soon and is not so wide, although it is as persistent as the band of the dioxime.

Curves of Molecular Vibrations.—(9) Quinone Dioxime.



QUINONE.

$C_6H_4O_2$.

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 c.c. *water.*		
5	Spectrum continuous to	3148	3176
	1st *Absorption band*	**3148–3568**	**3176–2802**
	Rays feebly transmitted	3568–3638	2802–2748
4	Spectrum continuous to	3175	3149
	1st *Absorption band*	**3175–3568**	**3149–2802**
	Rays feebly transmitted	3568–3638	2802–2748
3	Spectrum continuous to	3355	2980
	1st *Absorption band*	**3355–3471**	**2980–2881**
	Rays transmitted	3471–3693	2881–2707
2	Spectrum practically continuous to	3693	2707
	Still weak in position of absorption band.		
1	Spectrum continuous to	3754	2663
	1 *milligram-molecule in* 500 c.c. *water.*		
5 4 3	Spectrum continuous to	3754	2663
2	" "	3824	2615
	2nd *Absorption band*	**3824–4411**	**2615–2267**
	Line at.	4411	2267
1	Spectrum continuous to	3816	2620
	2nd *Absorption band*	**3816–4321**	**2620–2314**
	Spectrum transmitted.	4321–4656	2314–2147
	1 *milligram-molecule in* 2,500 c.c. *water.*		
5 4	Spectrum continuous to	3816	2620
	2nd *Absorption band*	**3816–4321**	**2620–2314**
	Rays transmitted.	4321–4656	2314–2147
3	Spectrum continuous to	3886	2573
	2nd *Absorption band*	**3886–4306**	**2573–2322**
	Rays transmitted.	4306–4656	2322–2147
2	Spectrum continuous to	3886	2573
	2nd *Absorption band*	**3886–4240**	**2573–2358**
	Rays transmitted.	4240–4656	2358–2174
1	Spectrum continuous practically to	4656	2174
	Still very weak in position of absorption band.		
	1 *milligram-molecule in* 12,500 c.c. *water.*		
5	Spectrum practically continuous to	4656	2147
	Still very weak in position of absorption band No. 2.		
4 and 3	Same as 5.		
2 and 1	Spectrum practically all transmitted.		

p-NITROSO-PHENOL.

$C_6H_4.OH.NO.$

Thickness in layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 c.c. *alcohol.*		
25	Spectrum continuous to . .	2354	4248
20	" " " . .	2462	4061
15 10	" " but stronger to	2462	4061
5	" " to . .	2502	3996
4 3 2	" " " . .	2502	3996
1	" " " . .	2673	3741
	1 *milligram-molecule in* 500 c.c. *alcohol.*		
5	Spectrum continuous to . .	2673	3741
4	" " " . .	2714	3684
	1st *Absorption band*	**2714–3886**	**3684–2573**
	Line showing feebly at . .	3886	2573
3	Spectrum continuous to . .	2768	3612
	1st *Absorption band*	**2768–3824**	**3612–2615**
	Rays transmitted	3824–3886	2615–2573
	2nd *Absorption band*	**3886–4321**	**2573–2314**
	Spectrum weak towards end .	4321–4555	2314–2195
2	Spectrum continuous to . .	2768	3612
	1st *Absorption band*	**2768–3824**	**3612–2615**
	Spectrum transmitted from . .	3824–3886	2615–2573
	2nd *Absorption band*	**3886–4306**	**2573–2322**
	Lines showing at	4119	2427
	" " "	4128	2422
	" " "	4245	2355
	Rays transmitted from . . .	4306–4656	2322–2147
	The latter part very weak and consisting of single lines only.		
1	Spectrum continuous to . .	2982	3353
	1st *Absorption band*	**2982–3568**	**3353–2802**
	Rays transmitted from . . .	3568–4656	2802–2147
	1 *milligram-molecule in* 2,500 c.c. *alcohol.*		
5	Spectrum continuous to . .	2982	3353
	1st *Absorption band*	**2982–3568**	**3353–2802**
	Rays transmitted from . . .	3568–4656	2802–2147
4	Spectrum continuous to . .	3064	3263
	1st *Absorption band*	**3064–3568**	**3263–2802**
	Rays transmitted from . . .	3568–4656	2802–2147
3	Spectrum continuous to . .	3148	3176
	1st *Absorption band*	**3148–3491**	**3176–2864**
	Rays transmitted from . . .	3491–4656	2864–2147
2	Spectrum practically continuous to	4656	2147
	But still weak in position of absorption band.		
1	Same as 2, but stronger.		

QUINONE CHLORIMIDE.

$C_6H_4O.N.Cl.$ M.P. 85°.

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 c.c. *alcohol.*		
5, 4	Spectrum continuous to . . .	2768	3612
3 2	,, ,, ,, . . .	2884	3467
1	,, ,, ,, . . .	3064	3263
	1 *milligram-molecule in* 500 c.c. *alcohol.*		
5 and 4	Spectrum continuous to . . .	3064	3263
3	,, ,, ,, . . .	3148	3176
2	,, ,, ,, . . .	3148	3176
	Absorption band	**3148–4321**	**3176–2314**
	Rays freely transmitted from . .	4321–4408	2314–2268
1	Spectrum continuous to . . .	3295	3034
	Absorption band	**3295–3886**	**3034–2573**
	Rays freely transmitted . . .	3886–4530	2573–2207
	1 *milligram-molecule in* 2,500 c.c. *alcohol*		
5	Spectrum continuous to . . .	3295	3034
	Absorption band	**3295–3886**	**3034–2573**
	Rays freely transmitted from . .	3886–4530	2573–2207
4	Spectrum continuous to . . .	3295	3034
	Absorption band	**3295–3816**	**3034–2620**
	Rays freely transmitted from . .	3816–4530	2620–2207
3	Spectrum continuous to . . .	3323	3009
	Absorption band	**3323–3816**	**3009–2620**
	Rays freely transmitted . . .	3816–4555	2620–2195
2	Spectrum continuous to . . .	3323	3009
	Absorption band	**3323–3521**	**3009–2840**
	Rays transmitted	3521–4656	2840–2147
1	Spectrum practically all transmitted; still weak in position of absorption band.		
	1 *milligram-molecule in* 12,500 c.c. *alcohol.*		
5, 4, 3	Spectrum practically all transmitted; still weak in position of absorption band.		
2, 1	Continuous spectrum transmitted.		

Quinone Dioxime.

$C_6H_4N_2(OH)_2$. M.P. 240°.

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 milligram-molecule in 20 c.c. alcohol.		
25 20 15 10	Spectrum continuous to	2354	4248
5 4 3	„ „	2503	3995
2	„ „	2545	3929
1	„ „	2673	3741
	1 milligram-molecule in 100 c.c. alcohol.		
5	Spectrum continuous to	2673	3741
4 3	„ „	2714	3684
2	„ „	2744	3644
	Absorption band	2744–4321	3644–2314
	Rays transmitted	4321–4413	2314–2266
1	Spectrum continuous to	2768	3612
	Absorption band	2768–4243	3612–2356
	Rays transmitted from	4243–4413	2356–2266
	1 milligram-molecule in 500 c.c. alcohol.		
5	Spectrum continuous to	2768	3612
	Absorption band	2768–4243	3612–2356
	Rays transmitted from	4243–4413	2356–2266
4	Spectrum continuous to	2768	3612
	Absorption band	2768–4112	3612–2431
	Rays transmitted from	4112–4534	2431–2205
3	Spectrum continuous to	2791	3582
	Absorption band	2791–4112	3582–2431
	Rays transmitted from	4112–4555	2431–2195
2	Spectrum continuous to	2791	3582
	Absorption band	2791–3886	3582–2573
	Rays very feebly transmitted from	3886–4656	2573–2147
1	Spectrum continuous to	2884	3467
	Absorption band	2884–3824	3467–2615
	Rays transmitted from	3824–4656	2615–2147
	1 milligram-molecule in 2,500 c.c. alcohol.		
5	Spectrum continuous to	2884	3467
	Absorption band	2884–3824	3467–2615
	Rays transmitted from	3824–4656	2615–2147
4	Spectrum continuous to	2884	3467
	Absorption band	2884–3638	3467–2748
	Rays transmitted from	3638–4656	2748–2147
3	Spectrum continuous to	2982	3353
	Absorption band	2982–3521	3353–2840
	Rays transmitted from	3521–4656	2840–2147
2	Spectrum continuous to	3063	3264
	Absorption band	3063–3470	3264–2881
	Rays transmitted from	3470–4656	2881–2147
1	Spectrum continuous to	3148	3176
	Absorption band	3148–3295	3176–3034
	Rays transmitted from	3295–4656	3034–2147
	(Spectrum nearly all transmitted.)		

QUINONE DIOXIME—*continued.*

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 12,500 *c.c. alcohol.*		
5	Spectrum continuous to . . .	3148	3176
	Absorption band	**3148–3295**	**3176–3034**
	Rays transmitted from . . .	3295–4656	3034–2147
	(Spectrum nearly all transmitted.)		
4	Spectrum practically all transmitted; still weak in position of absorption band.		
3	Spectrum practically all transmitted; still weak in position of absorption band.		
2 1	Spectrum all transmitted . . .		

QUINONE DICHLORIMIDE.

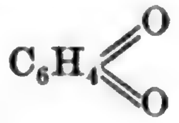
$C_6H_4N_2Cl_2$. M.P. 124°.

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
	1 *milligram-molecule in* 100 *c.c. alcohol.*		
5 4	Spectrum continuous to . . .	2630	3802
3	,, ,, ...	2714	3684
2	,, ,, ...	2768	3612
1	,, ,, ...	2795	3577
	1 *milligram-molecule in* 500 *c.c. alcohol.*		
5 4	Spectrum continuous to . . .	2795	3577
3	,, ,, ...	2884	3467
	Absorption band	**2884–3824**	**3467–2615**
	Rays very faintly transmitted . .	3824–4128	2615–2422
2	Spectrum continuous to . . .	2982	3353
	Absorption band	**2982–3824**	**3353–2615**
	Feebly transmitted	3824–4414	2615–2265
1	Spectrum continuous to . . .	3047	3281
	Absorption band	**3047–3638**	**3281–2748**
	Rays transmitted	3638–4539	2748–2203
	1 *milligram-molecule in* 2,500 *c.c. alcohol.*		
5	Spectrum continuous to . . .	3047	3281
	Absorption band	**3047–3638**	**3281–2748**
	Rays transmitted	3638–4539	2748–2203
4	Spectrum continuous to . . .	3064	3263
	Absorption band	**3064–3638**	**3263–2748**
	Rays transmitted	3638–4539	2748–2203
3	Spectrum continuous to . . .	3064	3263
	Absorption band	**3064–3521**	**3263–2840**
	Rays transmitted	3521–4656	2840–2147

QUINONE DICHLORIMIDE—*continued.*

Thickness of layer of liquid in millimetres	Description of Spectrum	$\frac{1}{\lambda}$	λ
2	Spectrum continuous to . . .	3064	3263
	Absorption band	**3064–3491**	**3263–2864**
	Rays transmitted	3491–4656	2864–2147
1	Spectrum continuous to . . .	3148	3176
	Absorption band	**3148–3471**	**3176–2881**
	Rays feebly transmitted in band at .	3295	3034
	and	3323	3009
	Spectrum transmitted . . .	3471 to 4656	2881 to 2147
	1 *milligram-molecule in* 12,500 *c.c. alcohol.*		
5	Spectrum continuous to . . .	3148	3176
	Absorption band	**3148–3471**	**3176–2881**
	Rays feebly transmitted in band at .	3295	3034
	and	3323	3009
	Rays transmitted	3471–4656	2881–2147
4	Spectrum continuous to . . .	3148	3176
	Absorption band	**3148–3478**	**3176–2881**
	Rays transmitted at	3295	3034
	and	3323	3009
	Rays transmitted	3471–4656	2881–2147
3	Spectrum practically all transmitted to	4656	2147
	But still very weak in position of absorption band.		
2 1	Spectrum all transmitted; still weak in position of absorption band.		

Lastly, it may be remarked that in the report for 1899, p. 345, there are some brief observations on the origin of colour and on fluorescence, which give a physical explanation of the cause of colour in a hydrocarbon; the observations are illustrated by reference to the constitution of triphenyl methane, a compound without any *visible colour*; of anthracene, which in the state of greatest purity is faintly coloured; and to bi-diphenylene ethylene, which is strongly coloured red. It would be difficult to account for these coloured substances by assuming a particular structure for quinone, and further assuming that all coloured substances and dyes had a structure similar to that of quinone. In connection with this subject reference may be made to some recent work of v. Baeyer and Villiger on dibenzylidene acetone and triphenyl methane.[1] They refer to the constitution of colourless substances which form highly coloured salts, and term the phenomenon *halochromism.* The colour is not due to a quinonoid constitution



$$C_6H_4\begin{cases}O\\O\end{cases}$$

for it is even shared by triphenyl methane; and, furthermore, these acetone derivatives are constituted in an essentially different manner from that of quinone and of the dyes and coloured substances formulated upon a similar typical structure.

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[1] *Ber.*, 1902, **35**, 1189–1201; also *C. Soc. J. Abstr.*, 1902, vol. i. pp. 112 and 380, June 1902.

Hydro-aromatic Compounds with Single Nucleus.

By ARTHUR W. CROSSLEY, *D.Sc.*, *Ph.D.*

[Ordered by the General Committee to be printed *in extenso*.]

WHEN hydrogen is added on to benzene, di-, tetra-, and hexa-hydrobenzene are obtained, and it has become customary to consider all homologues and derivatives of the three above-mentioned hydrocarbons under the name 'hydro-aromatic compounds.'[1] It is only of comparatively recent years that these bodies have been much investigated, stimulus to research being found in a knowledge of the fact that many groups of naturally occurring substances stand in the closest relationship to the hydro-aromatic bodies, notably, the terpenes and camphors, and the hydrocarbons of petroleum.

Strictly speaking, hydro-aromatic bodies do not come under the heading 'aromatic compounds'; for as soon as two hydrogen atoms are added on to the benzene ring the peculiar system of linkage which provides the characteristic aromatic properties is destroyed, and the resulting bodies exhibit the chemical behaviour of unsaturated aliphatic compounds (compare p. 131). This remains true when four hydrogen atoms are added to benzene, and when six hydrogen atoms are added there result hexahydrobenzene derivatives, which are almost identical in chemical deportment with the saturated aliphatic compounds.

In such a brief communication as the present it has been found impossible to deal with the enormous amount of recent work on the terpenes and camphors, and therefore the subject has been avoided; but in this report an attempt is made to refer to all the most important memoirs on the subject of hydro-aromatic compounds containing a single nucleus, and it is hoped that the result may prove useful to intending workers in this attractive field of research.

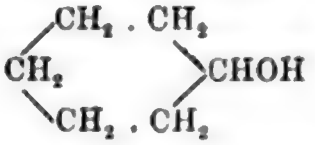
HYDROCARBONS.

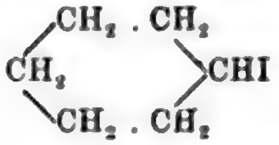
Hexahydrobenzene, C_6H_{12}, and its homologues (naphthenes) occur in various kinds of petroleum,[2] in the oil from bituminous shales,[3] and are produced during the 'cracking process.'[4]

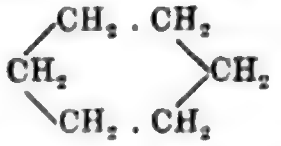
Hexahydrobenzene has been synthesised as follows:—

(i.) From hexamethylene dibromide and metallic sodium.[5]

(ii.) From hydroxyhexahydrobenzene (p. 123) by converting it into iodohexahydrobenzene, and reducing the latter with zinc and acetic acid.[6]







In the earliest attempts to prepare hexahydrobenzene from various benzene and hexahydrobenzene derivatives[7] hydriodic acid was employed as the reducing agent; but Markownikoff[1] has proved that this reagent acts on derivatives of hexahydrobenzene to produce tho isomeric methylcyclopentane

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[1] The term hydro-aromatic compounds also includes many derivatives of aromatic hydrocarbons containing condensed benzene nuclei.

[2] *Ber.*, 1895, **28**, 577, 1235; *Amer. Chem. J.*, 1897, **19**, 374, 419, 796; 1901, **25**, 284; *Annalen*, 1898, **301**, 154; *J.C.S.*, 1898, **73**, 905, 932.

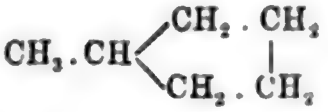
[3] *Ber.*, 1897, **30**, 2743.

[4] *Ber.*, 1897, **30**, 2908.

[5] Perkin, *Ber.*, 1894, **27**, 216.

[6] Baeyer, *Annalen*, 1894, **278**, 110.

[7] Berthelot, *Bull. Soc. Chim.*, 1867–8; Baeyer, *Annalen*, 1870, **155**, 266; Wreden, *Annalen*, 1877, **187**, 153; Kistner, *J. russ. Chem. Ges.*, 20 [2], 118.



$$CH_3.CH\left\langle\begin{array}{l}CH_2.CH_2\\ \quad\quad\quad |\\ CH_2.CH_2\end{array}\right.$$

although hexahydrobenzene itself is not acted on in this manner.[2]

(iii.) From a mixture of benzene and hydrogen under the influence of reduced nickel.[3]

The properties of hexahydrobenzene are typical of its homologues in so far as the latter have been studied. It is a liquid smelling like benzene; on cooling it solidifies, forming crystals (M.P. 6°·4) which belong to the cubic system, and therefore have no action on polarised light, thus differing from benzene.[4] Concentrated nitric acid has no action on it even after long standing, and a mixture of nitric and sulphuric acids acts very slowly at ordinary temperatures, but violently on warming, producing some nitro products, but principally adipic acid. Chlorine substitutes, but bromine has no action at ordinary temperatures, and at 100° gives rise to polybromides of methylcyclopentane.[5]

Physical properties[6]:—In an interesting paper on the molecular volumes and refractive constants of benzene, hydrobenzenes, and six carbon open-chain hydrocarbons Bruhl[7] shows that there is no great change in these constants in passing from benzene to di-, tetra-, or hexa-hydrobenzenes, as would be expected if the molecular structure of these bodies differed materially, whereas considerable differences are noticed in passing from hexahydrobenzene to the open-chain hydrocarbon hexane.[8]

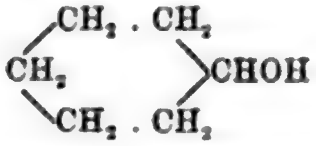
Substituted hexahydrobenzenes have been synthetised as follows:—

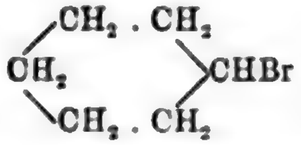
(i.) From substituted hydroxyhexahydrobenzenes by method (ii.) above.[9]

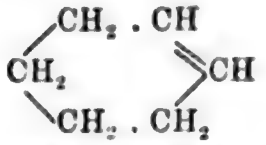
(ii.) From chlorhexahydrobenzene by the action of zinc alkyl compounds.[10]

(iii.) From substituted benzenes by method (iii.) above. Pure products are only obtained from benzene and toluene, the reaction being more complicated in the case of higher homologues.

Tetrahydrobenzene, C_6H_{10}.—When hydroxyhexahydrobenzene (p. 123) is treated with hydrogen bromide, bromohexahydrobenzene is obtained, from which quinoline removes the elements of hydrogen bromide, giving tetrahydrobenzene.[11]







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[1] *Annalen*, 1898, **302**, 1.

[2] See also *Ber.*, 1895, **28**, 1022, 1234, and 1897, **30**, 387, 1225; *J.C.S.*, 1898, **73**, 932.

[3] Sabatier and Senderens, *Compt. Rend.*, 1901, **132**, 1254.

[4] *Ber.*, 1901, **34**, 2799.

[5] *Annalen*, 1898, **302**, 1.

[6] *J.C.S.*, 1898, **73**, 932, and 1900, **77**, 372, 846.

[7] *Ber.*, 1894, **27**, 1065.

[8] See also Stohmann, *J. pr. Chem.* [2], **48**, 447.

[9] Zelinsky, *Ber.*, 1895, **28**, 781, 1343; 1896, **29**, 214; 1897, **30**, 1532; 1898, **31**, 3206; Knoevenagel, *Annalen*, 1897, **297**, 123.

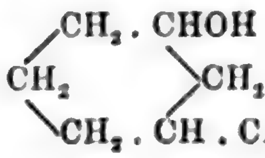
[10] Kursanoff, *Ber.*, 1899, **32**, 2972.

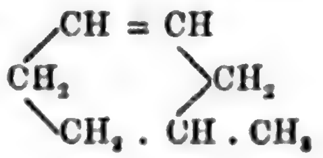
[11] Baeyer, *Annalen*, 1894, **278**, 107.

It has also been obtained from chlorhexahydrobenzene (from petroleum) by eliminating hydrogen chloride,[1] or by treatment with zinc ethyl.[2]

Tetrahydrobenzene is a colourless liquid, resembling petroleum, with a slight odour of garlic. On long standing it resinifies; it gives a yellow colour with sulphuric acid, and yields a liquid dibromide, crystalline nitrosochloride, and nitrosate. *Physical properties*, see *infra.*[3]

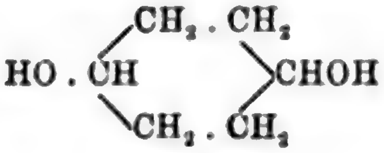
Substituted tetrahydrobenzenes.—In 1896 Knoevenagel[4] described a series of hydrocarbons supposed to be dihydrobenzenes, but which, at a later date,[5] were proved to be tetrahydrobenzenes. They were prepared by eliminating the elements of water from hydroxyhexahydrobenzenes (see pp. 124, 129) under the influence of phosphorus pentoxide.

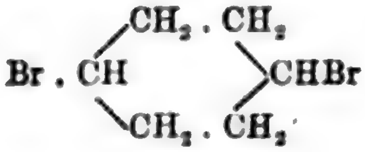


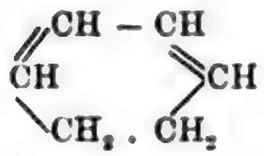


Optically active methyltetrahydrobenzenes have been described by Zelinsky.[6]

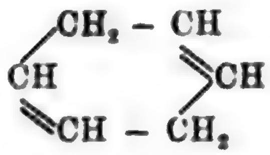
Dihydrobenzene, C_6H_8.—This hydrocarbon was first prepared by Baeyer[7] from 1 : 4-dihydroxyhexahydrobenzene (quinite) (p. 124), which with hydrobromic acid gives 1 : 4-dibromohexahydrobenzene. The latter readily loses two molecules of hydrogen bromide, yielding dihydrobenzene, for which, as Baeyer points out, there are two possible formulæ :—







or



Markownikoff,[8] who prepared dihydrobenzene from dichlorhexahydrobenzene, obtained from light petroleum,[9] considers Baeyer's hydrocarbon to be a mixture, as its tetrabromide on crystallisation yields fractions of different melting-points.

Dihydrobenzene is a liquid resembling benzene, but having a marked odour of garlic : like the terpenes, it resinifies on exposure to air, and gives a blue colour with sulphuric acid. It rapidly decolorises potassium permanganate, gives only traces of a crystalline nitrosochloride, a saturated hydrobromide and tetrabromide.[10]

Substituted dihydrobenzenes can be obtained as follows :—

(i.) From substituted 1 : 4-dihydroxyhexahydrobenzenes by the above method.[11]

---

[1] Markownikoff, *Annalen*, 1898, **302**, 27 ; Fortey, *J.C.S.*, 1898, **73**, 941.

[2] Kursanoff, *Ber.*, 1899, **32**, 2974.

[3] Fortey, *supra* ; also Hartley and Dobbie, *J.C.S.*, 1900, **77**, 84.

[4] *Annalen*, **289**, 131.

[5] *Annalen*, 1897, **297**, 113.

[6] *Ber.*, 1902, **35**, 2492.

[7] *Annalen*, 1894, **278**, 88.

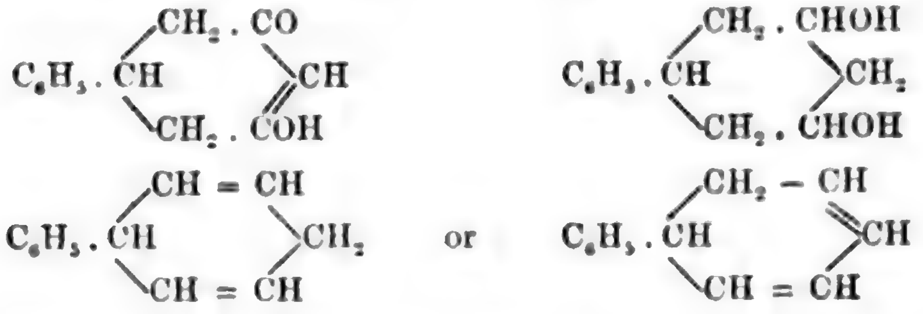
[8] *Ibid.*, 1898, **302**, 29.

[9] See also Fortey, *J.C.S.*, 1898, **73**, 944

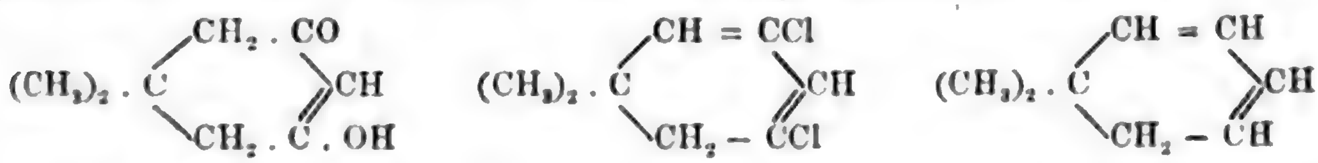
[10] Baeyer, *Annalen*, 1894, p. 95.

[11] Baeyer, *Ber.*, 1892, **25**, 2122 ; and 1893, **26**, 232.

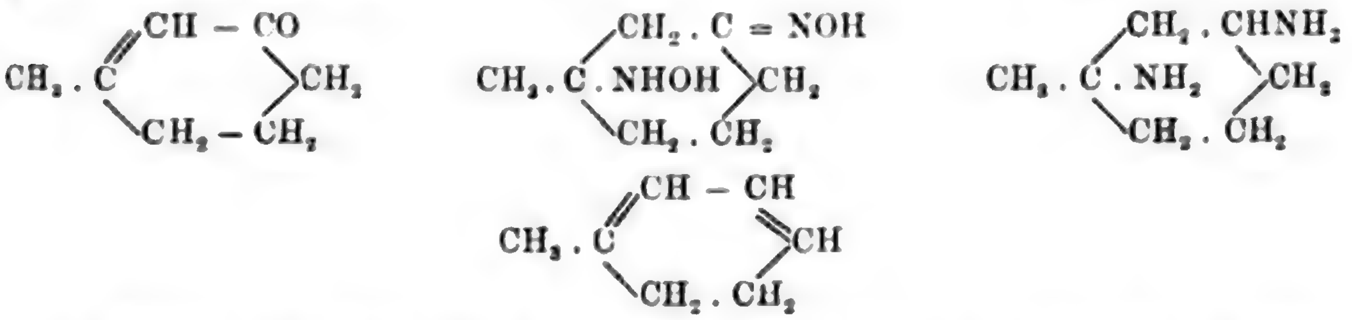
(ii.) From substituted dihydroresorcins (p. 127), which on reduction yield dihydric alcohols, and these readily give up the elements of water.[1]



(iii.) From substituted dihydroresorcins by treatment with phosphorus pentachloride and reduction of the resulting dichlorodihydrobenzenes.[2]



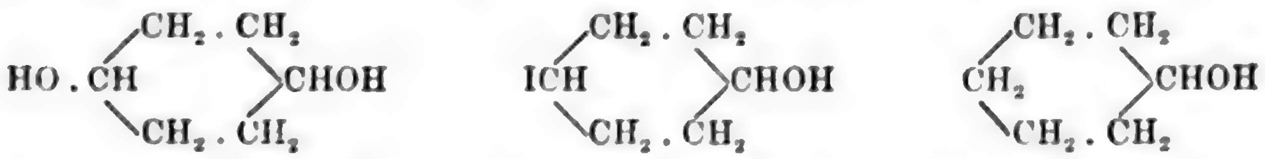
(iv.) From the hydroxylaminoximes of ketotetrahydrobenzenes, which on reduction give diamines, and these on heating with phosphoric acid give the hydrocarbons.[3]



Methods (ii.) and (iii.) have only been so far worked out in one case each, and it cannot be said if they are of general applicability. Methods (iii.) and (iv.) possess the advantage of giving pure hydrocarbons, as has been shown from a careful study of their oxidation products.

ALCOHOLS.

Hydroxyhexahydrobenzene was obtained by Baeyer[4] as a reduction product of ketohexahydrobenzene (pimeloketone, p. 125), or from 1 : 4-dihydroxyhexahydrobenzene (quinite, p. 124), which, with hydriodic acid, gives 1 : 4-iodohydroxyhexahydrobenzene, and this latter, on reduction with zinc dust and acetic acid, gives the alcohol :—[5]



It has an odour like fusel oil, melts at 15°, and is more readily soluble in water than the aliphatic alcohols containing six carbon atoms. It is unacted upon by potassium permanganate, but nitric acid readily oxidises it to adipic acid.

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[1] Knoevenagel, *Annalen*, 1896, **289**, 137.

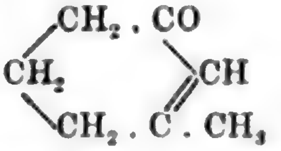
[2] Crossley and Le Sueur, *J.C.S.*, 1902, **81**, 821.

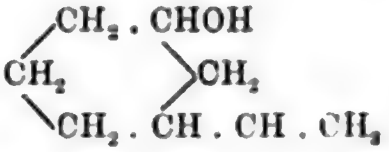
[3] Harries, *Ber.*, 1901, **34**, 300; 1902, **35**, 1166.

[4] *Ber.*, 1893, **26**, 229; *Annalen*, 1894, **278**, 98.

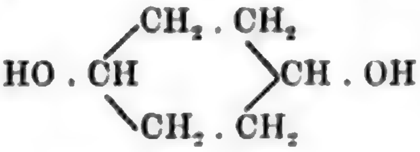
[5] See also *Annalen*, 1898, **302**, 20.

Homologues have been obtained from substituted ketohexahydrobenzenes (p. 126) by reduction[1] or by the action of magnesium and alkyl iodides ;[2] also from ketotetrahydrobenzenes (p. 128) by the action of sodium in alcoholic solution :—[3]





1 : 4-*Dihydroxyhexahydrobenzene* (quinite)

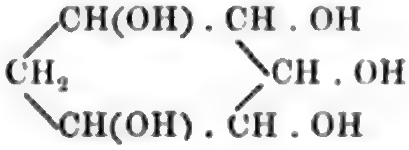


the simplest member of the inosite series is produced by the reduction of diketohexahydrobenzene (p. 128). It is a solid which tastes sweet at first, then bitter, and on oxidation with chromic acid is converted into quinone.[4] Homologues can be obtained in an analogous manner from substituted diketohexahydrobenzenes.[5]

Substituted 1 : 3-*dihydroxyhexahydrobenzenes* result from the reduction of substituted dihydroresorcins ;[6] 1 : 2-*dihydroxyhexahydrobenzene* ;[7] 1 : 3 : 5-*trihydroxyhexahydrobenzene* (phloroglucite).[8]

In this group must also be included quercite and inosite, formerly classed with the sugars.

Pentahydroxyhexahydrobenzene (quercite) occurs in acorns, the aqueous extract of which can be freed from glucose by fermentation, leaving quercite unaltered. The pure substance crystallises in monoclinic prisms, melting at about 225°, and is optically active $[\alpha]_D = +\ 24^\circ{\cdot}24$. It yields many well-characterised compounds, among which may be mentioned the pentanitrate and pentacetate. The following formula



was suggested by Kannonikow after Prunier[9] had shown that hydriodic acid converts quercite into benzene, phenol, iodophenol, quinone, and hydroquinone, and fusion with potash gives rise to hydroquinone and pyrogallol. Kiliani and Scheibler[10] doubted this formula, as they could only obtain mucic and trihydroxyglutaric acids by oxidising quercite with nitric acid ; but in 1896 Kiliani and Schäfer[11] showed that potassium permanganate oxidises quercite to oxalic and chiefly malonic acids, thus proving the presence of a methylene group, which fact, in conjunction with the above data, definitely proves Kannonikow's formula to be the true one.

Hexahydroxyhexahydrobenzene (inosite) is known in one inactive and two active modifications, its occurrence in optically active forms being satisfactorily explained by Baeyer's suggestions,[1] which would suppose the hydroxyl groups to occupy different positions relatively to the plane of the hexamethylene ring. The inactive variety occurs in muscle,[2] &c., and as its monomethyl ether (bornesite), $C_6H_6(OH)_5 . OCH_3$, and dimethyl ether (dambosite) in caoutchouc.[3] *d*-Inosite and *l*-inosite are obtained from their monomethyl ethers, respectively pinite[4] and quabrachite,[5] by the action of hydriodic acid.

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[1] Zelinsky, references, p. 7.

[2] Zelinsky, *Ber.*, 1901, **34**, 2877.

[3] Knoevenagel, *Annalen*, 1896, **289**, 131 ; and 1897, **297**, 113.

[4] Baeyer, *Ber.*, 1892, **25**, 1037.

[5] Baeyer, *ibid.*, 2122 ; and 1893, **26**, 232.

[6] Knoevenagel, *Annalen*, 1896, **289**, 187.

[7] *Annalen*, 1898, **302**, 21.

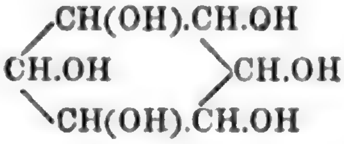
[8] Wislicenus, *Ber.*, 1894, **27**, 357.

[9] *Ann. Chim. Phys.*, 1879 [5], **15**, 1.

[10] *Ber.*, 1889, **22**, 517.

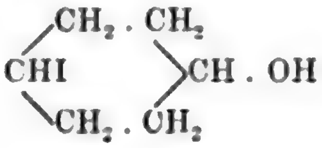
[11] *Ber.*, **29**, 1762.

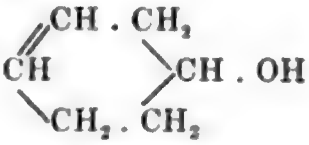
The constitution of inosite results from the work of Maquenne,[6] who suggested the formula[7]



It gives a hexacetate;[8] with hydriodic acid yields benzene and triodophenol; is oxidised completely to carbon dioxide by potassium permanganate; and with nitric acid gives the same oxidation products as hexahydroxybenzene, namely, di- and tetra-hydroxyquinone.

Hydroxytetrahydrobenzene is formed when 1 : 4-iodohydroxyhexahydrobenzene (p. 123) is treated with quinoline.[9]





AMINES.

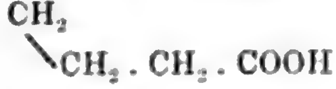
Hydro-aromatic amines result from the reduction of the corresponding oximes.

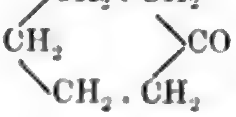
Aminohexahydrobenzene, $C_6H_{11} . NH_2$, obtained as above,[10] or by reducing nitrohexahydrobenzene with tin and hydrochloric acid,[11] is a colourless liquid smelling like conine.

1 : 2 - *Diaminohexahydrobenzene*,[12] 1 : 3 - *diaminohexahydrobenzene*,[13] 1 : 4-*diaminohexahydrobenzene*,[14] *tetrahydrobenzylamine*.[15]

KETONES.

Ketohexahydrobenzene (pimeloketone) has been obtained (i.) by the oxidation of hydroxyhexahydrobenzene,[16] (ii.) by the distillation of calcium pimelate with lime,[17]





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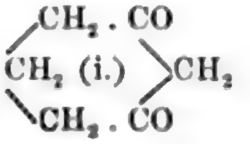
[1] *Annalen*, 1888, **245**, 128.
[2] *Beilstein*, 3te *Aufl.*, i. 1050.
[3] Girard, *Zeit. für Chem.*, 1871, 335.
[4] Maquenne, *Compt. Rend.*, 1890, **109**, 968.
[5] Tanret, *Compt. Rend.*, **109**, 908.
[6] *Compt. Rend.*, 1887, **104**, 225.
[7] *Ibid.*, p. 297.
[8] *Ibid.*, p. 1719.
[9] Baeyer, *Annalen*, 1894, **278**, 97.
[10] Baeyer, *Ibid.*, 103.
[11] Markownikoff, *Annalen*, 1898, **302**, 22.
[12] *Annalen*, 1897, **295**, 187.
[13] *Ibid.*, 1885, **228**, 39.
[14] *Ber.*, 1894, **27**, 1449.
[15] *J.C.S.*, 1901, *Abstr.*, i. 691.
[16] Baeyer, *Annalen*, 1894, **278**, 107.
[17] Baeyer, *ibid.*

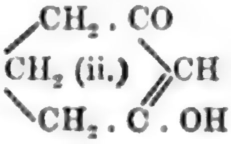
and (iii.) by the action of zinc and acetic acid on nitrohexahydrobenzene.[1] It is a liquid with an odour of peppermint, and is readily oxidised by nitric acid to adipic acid. Homologues have been prepared by method (ii.) from substituted pimelic acids.[2]

Of the three possible isomeric diketones two, viz., the 1 : 3- and 1 : 4-compounds are known.

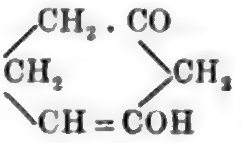
Dihydroresorcin (1 : 3-diketohexahydrobenzene) was first prepared by Merling[3] by the reduction of resorcinol with sodium amalgam; it can also be obtained by the action of sodium ethylate on ethyl δ-ketohexoate.[4]

Dihydroresorcin reacts in some cases as a diketone, but its most usual form is that of a ketone alcohol.

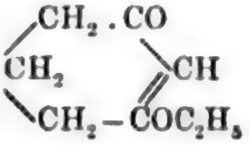




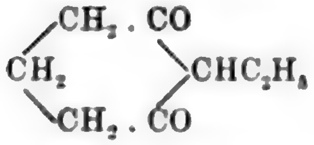
It is a crystalline substance which dissolves in water with an intense acid reaction; the solution gives a violet colour with ferric chloride, decomposes the carbonates of the alkali metals and silver in the cold, with the formation of salts, formula (ii.). It is readily oxidised by potassium permanganate, yielding glutaric acid, thus showing that it could not have the constitution represented by the formula



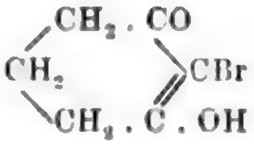
Alkyl iodides react with the silver salt, forming ethers



and not



because they are easily hydrolysed with regeneration of dihydroresorcin. With acetyl chloride only a mono-acetylated product is obtained; and with halogen acids or bromine additive products. The dibromide formed in the latter case readily loses the elements of hydrogen bromide, giving monobromodihydroresorcin, having the formula



because it decomposes the carbonates of the alkali metals, gives a violet colour with ferric chloride, and nascent hydrogen regenerates dihydroresorcin.[5]

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[1] *Annalen*, 1898, **302**, 19.

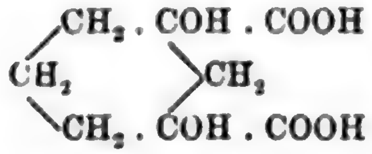
[2] Zelinsky, *Ber.*, 1895, **28**, 781, 1343, 2944; and 1896, **29**, 214, 731.

[3] *Annalen*, 1894, **278**, 20.

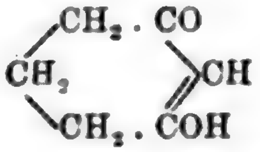
[4] Vorländer, *Annalen*, 1897, **294**, 253.

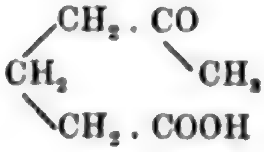
[5] Compare Vorländer, *Annalen*, 1902, **322**, 251.

Towards hydroxylamine, phenylhydrazine, and hydrocyanic acid dihydroresorcin behaves as a diketone, formula (i.) above, giving in the latter case the nitrile of dihydroxyhexahydroisophthalic acid



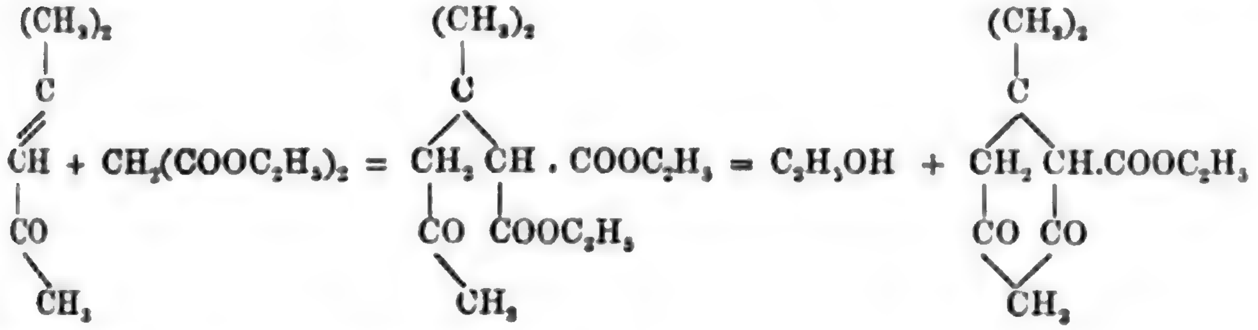
When heated with barium hydroxide the ring is broken, and δ-ketohexoic acid produced[1]





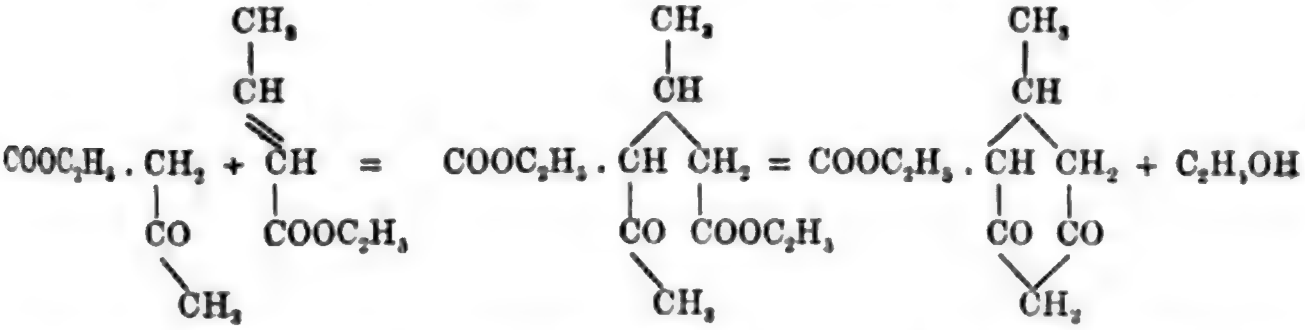
Substituted dihydroresorcins may be obtained by various methods,[2] of which the two following may be taken as typical:—

(i.) The condensation of ethyl malonate with $\alpha\beta$-unsaturated ketones.[3]

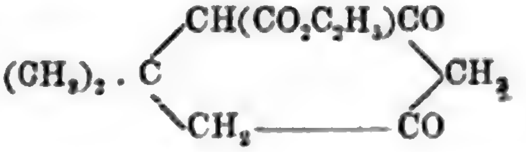


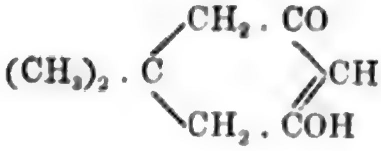
Substituted malonic acids may also be employed.[4]

(ii.) The condensation of ethyl aceto-acetate and ethyl crotonate.[5]



The ethyl dihydroresorcylates produced by either of the above methods on hydrolysis give free acids, which immediately lose carbon dioxide, forming dihydroresorcins.





The properties of substituted dihydroresorcins are identical with those of the initial member of the series. The above-mentioned behaviour with barium hydroxide seems to be somewhat limited, as exceptions are found in the cases of dimethyl- and trimethyl-dihydroresorcins

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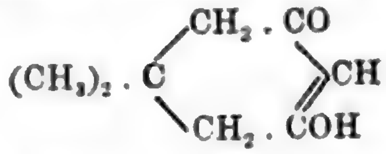
[1] Vorländer, *Annalen*, 1897, **294**, 272.

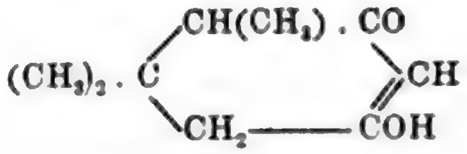
[2] *Ber.*, 1894, **27**, 2053, 2126, 2338.

[3] Vorländer, *supra*, p. 253; Crossley, *J.C.S.*, 1899, **75**, 771; 1902, **81**, 675.

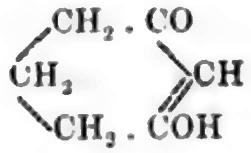
[4] Crossley, *J.C.S.*, 1901, **79**, 138.

[5] Vorländer, *Annalen*, 1899, **308**, 184.





neither of which gives the corresponding ketonic acids. Apparently it is the presence of two alkyl groups attached to one carbon atom which determines the behaviour of barium hydroxide,[1] as this is the only difference in constitution between the above and other dehydroresorcins which are hydrolysed when heated with barium hydroxide.[2] From a consideration of the electric conductivities Schilling and Vorländer[3] conclude that the acidic properties of dihydroresorcins are as strongly marked as those of δ-ketonic acids, although the carboxyl group is absent in the former. Structural difference between the two classes of compounds does not amount to much more than ring formation



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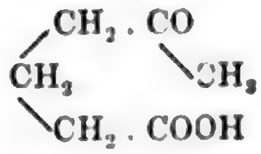
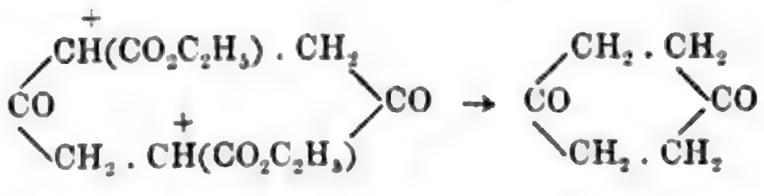


and cyclic organic compounds containing oxygen exhibit acidic properties more pronounced than those open-chain compounds of similar constitution.

Substituted glutaric acids result from the oxidation of substituted dihydroresorcins, a reaction best carried out by the employment of sodium hypobromite as oxidising agent.[4]

1 : 4-*Diketohexahydrobenzene* results when dry succinosuccinic acid is heated,[5] and from the saponification of ethyl succinosuccinate (p. 133) with strong sulphuric acid.[6]



As the hydrogen atoms marked + are replaceable by sodium, this reaction may be extended to the preparation of substituted diketohexahydrobenzenes. Allusion has been already made to the properties and transformations of these bodies.

Halogen derivatives of the above ketones may be obtained by the continuous action of chlorine or bromine on phenols, quinones, &c.[7]

Ketotetrahydrobenzenes have been found in the heavy oil produced by the distillation of wood tar.[8]

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[1] Crossley, *J.C.S.*, 1902, **81**, 675.

[2] Vorländer, *Annalen*, 1897, **294**, 317.

[3] *Annalen*, 1899, **308**, 184.

[4] Komppa, *Ber.*, 1899, **32**, 1421; Crossley, *J.C.S.*, 1901, **79**, 146; 1902, **81**, 680.

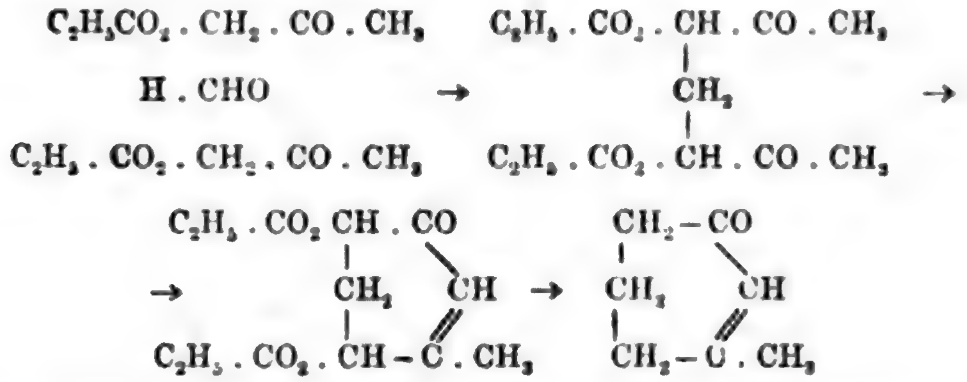
[5] *Ber.*, 1889, **22**, 2168.

[6] Baeyer, *Annalen*, 1894, **278**, 88.

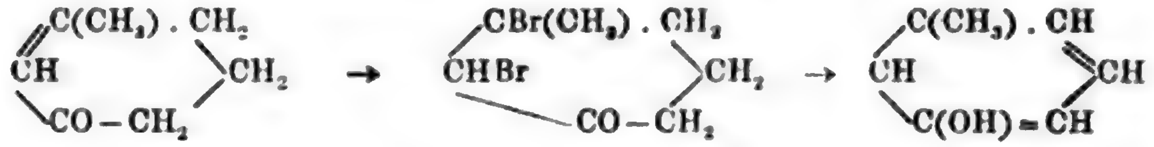
[7] *Ber.*, 1889, **22**, 1473; 1891, **24**, 912; 1892, **25**, 845.

[8] *Compt. Rend.*, 1897, **125**, 1036; 1901, **132**, 342.

Knoevenagel[1] has shown that by the condensation of ethyl acetoacetate, &c., with alkyl diiodides or aldehydes in presence of diethylamine or piperidine, esters of 1 : 5-diketocarboxylic acids are produced, which readily form ring compounds with loss of the elements of water; and the free acids generated from these bodies on hydrolysis lose carbon dioxide, giving ketotetrahydrobenzenes



Some of the more important reactions of these substances have been mentioned; a further property of peculiar interest is their ready transformation into aromatic derivatives; *e.g.*, 1-keto-3-methyl-Δ_2-tetrahydrobenzene readily absorbs two atoms of bromine; the product formed is unstable, losing two molecules of hydrogen bromide, giving meta-cresol,[2]



1-keto-3-methyl-5-isopropyl-Δ_2-tetrahydrobenzene under similar conditions gives *sym*-carvacrol.[3]

Halogen substitution products of ketotetrahydrobenzenes result from the action of chlorine on phenols, aniline, &c.[4]

Ketodihydrobenzenes.—Neither of the two theoretically possible isomerides is known; but tetra- and hexa-chloro-derivatives have been prepared.[5]

CARBOXYLIC ACIDS.

Hexahydrobenzoic acid has been obtained by the reduction (i.) of benzoic acid,[6] (ii.) of the hydrobromide of Δ_2-tetrahydrobenzoic acid,[7] and (iii.) of hydroxyhexahydrobenzoic acid,[8] and also by the hydrolysis and distillation of the product resulting from the action of ethyl sodiomalonate and pentamethylenedibromide,[9] and by the distillation of pentamethylenedicarboxylic acid.[9] *Tetrahydrobenzoic acids* have been prepared by the removal of hydrogen bromide from monobromohexahydrobenzoic acid,[10] and by the direct reduction of benzoic[11] and dihydrobenzoic acids,[1] and *dihydrobenzoic acids* from the oxidation of dihydrobenzaldehyde,[2] and by the action of alcoholic potash on dibromo-Δ_2-tetrahydrobenzoic acid.[3] Homologues result from the reduction of homologues of benzoic acid,[4] and by heating hexamethylene dicarboxylic acids.[5] In chemical properties these acids exhibit great similarity with the hydrophthalic acids (which see below). The hexahydro-acids appear to be isomeric, but not identical with the natural naphthenic acids occurring in petroleum.[6]

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[1] *Annalen*, 1894, **281**, 25; 1895, **288**, 321: and 1895, **289**, 131.

[2] *Ber.*, 1893, **26**, 1951; *Annalen*, 1894, **281**, 98.

[3] *Ber.*, 1894, **27**, 2347.

[4] *Ber.*, 1890, **23**, 3777; 1892, **25**, 2688; 1894, **27**, 547, 550, 560.

[5] Zincke, *Ber.*, 1894, **27**, 546.

[6] Markownikoff, *Ber.*, 1892, **25**, 3357.

[7] Aschan, *Annalen*, 1892, **271**, 261.

[8] Bucherer, *Ber.*, 1894, **27**, 1231.

[9] Perkin and Haworth, *J.C.S.*, 1894, **65**, 103.

[10] *Annalen*, **271**, 261.

[11] *Ibid.*, 234.

Hydroxyhexahydrobenzoic acids,[7] *dihydroxyhexahydrobenzoic acid,*[8] *tetrahydroxyhexahydrobenzoic acid* (quinic acid),[9] *pentahydroxyhexahydrobenzoic acid,*[10] *trihydroxytetrahydrobenzoic* (*shikimic*) *acid.*[11]

Ketohexahydrobenzoic acid,[12] *diketohexahydrobenzoic acid* (ethyl resorcylates) (see p. 127).

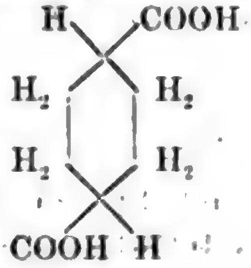
Hydrophthalic Acids.

The hydrophthalic acids have been minutely studied by Baeyer in his investigations on the constitution of benzene,[13] and these papers must be consulted for a detailed description. Here it is only possible to mention some of the more important properties, which show the striking resemblance between these bodies and acids of the aliphatic series.

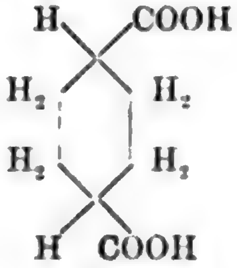
Generally speaking the di- and tetra-hydro-acids were obtained by the direct reduction of the phthalic acid, and the hexahydro-acids by the reduction of the hydrobromide of the tetrahydro-acid.

Some idea of the numerous isomerides may be gained from the following scheme, which shows the constitution and nomenclature [14] of the ten possible hydroterephthalic acids. In the case of the orthophthalic acids there are fifteen possibilities; and trans-hexahydrophthalic acid can exist in two optically active forms.[15]

Hexahydroterephthalic acid, $C_6H_{11}(COOH)_2$.—Two possibilities depending on the position of the carboxyl groups relative to the plane of the hexamethylene ring.



Cis trans.



Cis.

Tetrahydroterephthalic acid, $C_6H_8(COOH)_2$.—Depending on the position of the double bonds, theoretically possible in two isomeric forms, one of which can exist in two stereoisomeric modifications.

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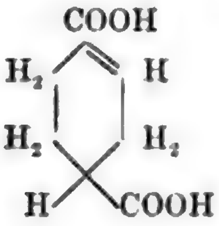
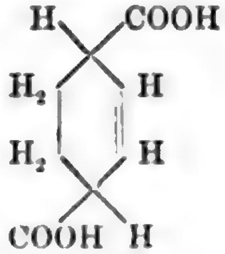
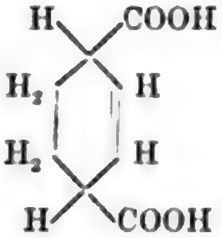
[1] *Ber.*, 1893, **26**, 451.
[2] *Ibid.*, p. 454.
[3] Aschan, *Ber.*, 1891, **24**, 2623.
[4] *Ber.*, 1892, **25**, 3355; 1894, **27**, R. 195; *J.C.S.*, 1897, **71**, 157; 1901, **79**, 344, 1379.
[5] Perkin and Freer, *J.C.S.*, 1888, **53**, 208.
[6] *Ber.*, 1892, **25**, 3665; 1894, **27**, R. 195, 197.
[7] *Ber.*, 1894, **27**, 1231, 2472, 2476; 1896, **29**, R. 549.
[8] *Annalen*, **271**, 280.
[9] *Beilstein*, 3te *Aufl.*, i. 804.
[10] *Ber.*, 1891, **24**, 1294.
[11] *Ber.*, 1891, **24**, 1279.
[12] *Ber.*, 1894, **27**, 103; 1896, **29**, R. 550.
[13] *Annalen*, 1888, **245**, 107; 1889, **251**, 257; 1890, **256**, 1; **258**, 1, 145; 1891, **266**, 169; 1892, **269**, 145; also Villiger, *Annalen*, 1893, **276**, 255.
[14] For an explanation of which see *Annalen*, 1888, **245**, 107.
[15] Werner and Conrad, *Ber.*, 1899, **32**, 3046.



Δ_1.

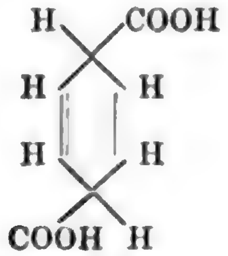


Cis trans Δ_2.

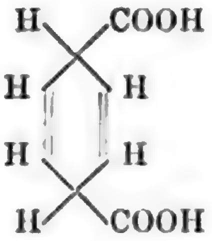


Cis Δ_2.

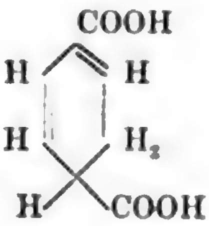
Dihydroterephthalic acid, $C_6H_6(COOH)_2$.—Four possibilities depending on the position of the double bonds : one possibility appears in two stereoisomeric modifications.



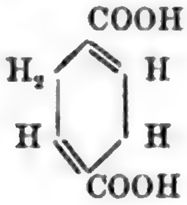
Cis trans $\Delta_{2:5}$.



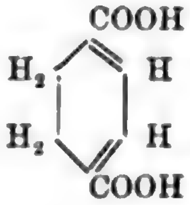
Cis $\Delta_{2:5}$.



$\Delta_{1:5}$.

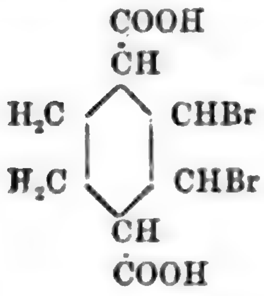


$\Delta_{1:4}$.

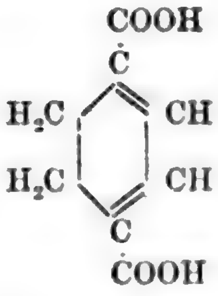


$\Delta_{1:3}$.

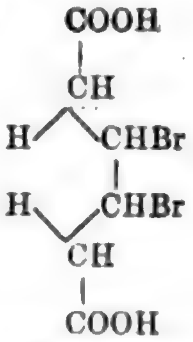
As regards the resemblance to aliphatic compounds, the hexahydro-acids do not give addition compounds with bromine, but substitution products in which the bromine, as in the fatty series, occupies the α-position. The tetrahydro-acids take up $H_2 : Br_2$ or HBr, forming hexahydro-compounds, and the dihydro-acids combine with $H_2 : Br_2$ or HBr, forming tetrahydro-derivatives or with $2H_2 : 2Br_2$ or 2HBr, forming hexahydro-derivatives ; just as fatty compounds with two double bonds yield successively ethylene derivatives and saturated fatty substances. When a tetrahydro-acid absorbs hydrogen bromide the bromine atom occupies the position more remote from the carboxyl group, resembling, for example, the production of β-bromopropionic acid from acrylic acid and hydrogen bromide. The bromo-acids on treatment with nascent hydrogen have the bromine replaced by hydrogen, or if they contain two bromine atoms united to adjacent carbon atoms then both bromine atoms are removed (i.) by nascent hydrogen with formation of a double bond, or (ii.) by alcoholic potash with formation of two double bonds.



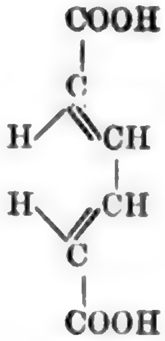
2 : 3-Dibromohexahydroterephthalic acid.



$\Delta_{1:3}$ Dihydroterephthalic acid.



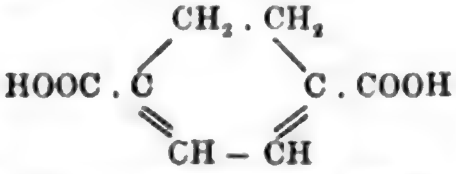
βγ-Dibromadipic acid.



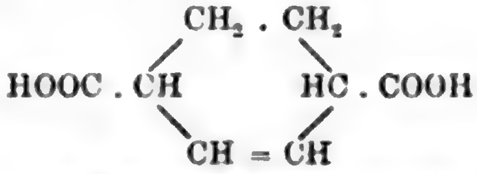
Muconic acid.

And when these di- or tetra-hydro-compounds are oxidised with potassium permanganate, the ring is broken at the double bonds, just as in the case of unsaturated fatty compounds.

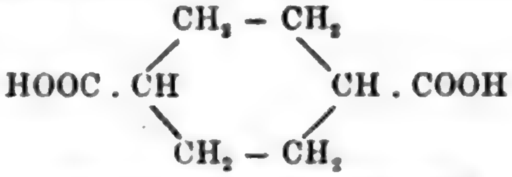
A further analogy is to be found in the gradual reduction by nascent hydrogen of $\Delta_{1:3}$-dihydroterephthalic acid and muconic acid.



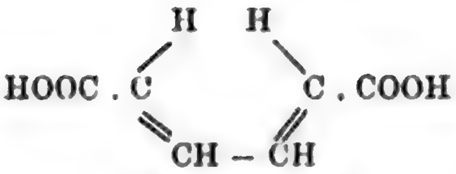
$\Delta_{1:3}$-Dihydroterephthalic acid.



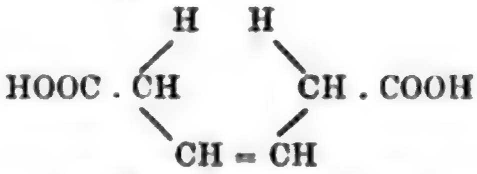
Δ_{2}-Tetrahydroterephthalic acid.



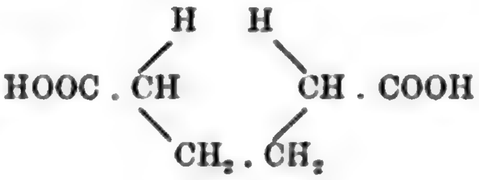
Hexahydroterephthalic acid.



Muconic acid.

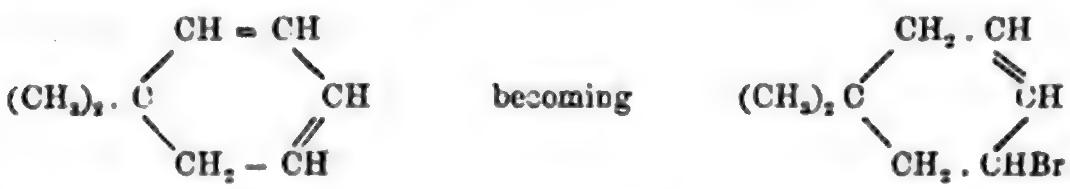


βγ-Hydromuconic acid.

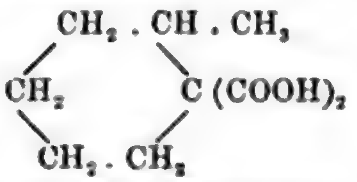


Adipic acid.

The first stage of this reduction is of special interest in view of Thiele's theory of partial saturation.[1] Baeyer states[2] that all $\Delta_{1:3}$ or $\Delta_{1:5}$ dihydro-acids—that is, those containing two double bonds in the above positions—form only dibromides, whereas other dihydro-acids form tetrabromides, and a similar case has been noticed in dimethyl-$\Delta_{2:4}$-dihydrobenzene,[3] for only two atoms of bromine or one molecule of hydrogen bromide can be directly added to this substance, the addition taking place, as in the case of hydrogen, to $\Delta_{1:3}$-dihydroterephthalic acid, with rearrangement of the bonds,



Various hexahydro-dicarboxylic acids have also been synthetically prepared; for example, when methylpentamethylene dibromide is condensed with ethyl sodiomalonate there results the ethyl salt of 2-*methylhexahydrobenzene*-1 : 1-*dicarboxylic acid*,[4]



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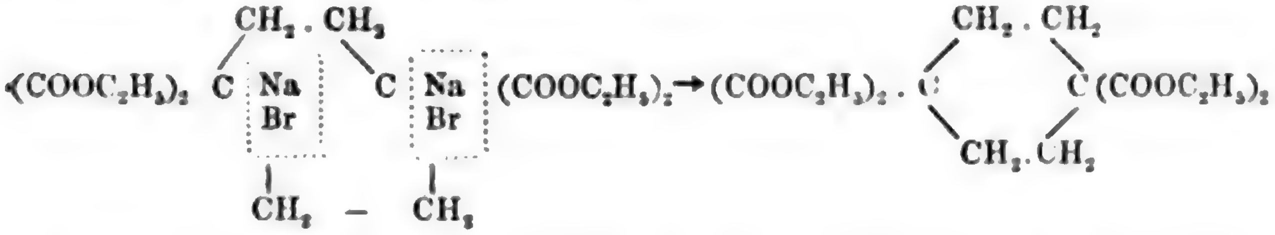
[1] *Annalen*, 1899, **306**, 87.

[2] *Ibid.*, 1890, **258**, 2.

[3] Crossley and Le Sueur, *J.C.S.*, 1902, **81**, 823.

[4] Perkin and Freer, *J.C.S.*, 1888, **53**, 202.

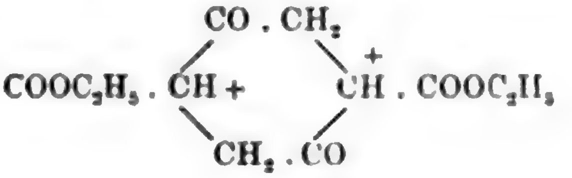
and hexahydroterephthalic acid is obtained by saponification and elimination of $2CO_2$ from the product of the interaction of ethylene dibromide and ethyl sodiobutanetetracarboxylate,[1]



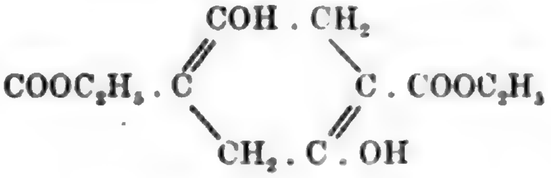
a reaction which may be extended to the preparation of hexahydroisophthalic acid,[2] in which case both the cis and trans modifications were obtained.[3]

Hydroxy- and ketohydro-dicarboxylic acids.—Dihydroxyhexahydroisophthalic acid (see above), 1 : 4-*dihydroxyhexahydroterephthalic acid*, results from the addition of hydrocyanic acid to diketohexahydrobenzene[4] and the ethyl salts of 2 : 5-*dihydroxytetra-* and *hexahydroterephthalic acid* by the reduction of ethyl succinosuccinate.[5]

Succinosuccinic acid is formed by the saponification of its ethyl salt



prepared by the action of potassium or sodium on ethyl succinate, &c.[6] The ethyl salt is capable of reacting in two forms, as a diketone or as ethyl dihydroxydihydroterephthalic acid.[7]



The two hydrogen atoms (marked above +) can be replaced by sodium, thus affording a method for the production of homologues. The chemical changes which this substance is capable of undergoing have been frequently alluded to.

Ethyl dihydroxydiketohexahydrobenzenedicarboxylate,[8] *ethyl diketohexahydrobenzenetetracarboxylate*,[9] *hexahydrobenzenehexacarboxylic (hexahydromellitic) acid*.[10]

In conclusion it may be of interest to draw attention to the close relationship existing between aliphatic, hydro-aromatic, and aromatic bodies, as illustrated by the passage of substances belonging to the aliphatic series into hydro-aromatic bodies, and of the latter into members of the aromatic series ; and also to point out, as far as our present somewhat scanty knowledge regarding hydro-aromatic bodies will permit, the resemblances and differences in the properties and reactions of these three series of bodies.

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[1] Mackenzie and Perkin, *J.C.S.*, 1892, **61**, 172.

[2] Perkin, *J.C.S.*, 1891, **59**, 798.

[3] Compare Villiger, *Annalen*, 1893, **276**, 255.

[4] *Ber.* 1889, **22**, 2176.

[5] *Ber.*, 1900, **33**, 390.

[6] *Annalen*, 1882, **211**, 306; 1888, **245**, 74; 1889, **253**, 182.

[7] *Ber.*, 1891, **24**, 2692.

[8] *Ber.*, 1886, **19**, 2385; 1887, **20**, 1307; 1889, **22**, 1290; 1890, **23**, 265.

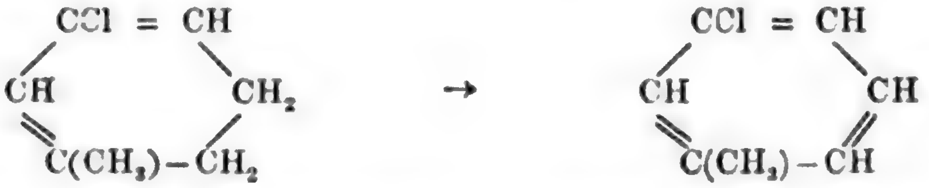
[9] *Ber.*, 1889, **22**, R. 289.

[10] *Beilstein*, 3te *Aufl.*, ii. 2104.

Many instances have already been quoted of the ring formation of hydro-aromatic substances from open-chain compounds : *e.g.*,

The preparation of hexahydrobenzene by method (i.), p. 120.
,, ,, ketohexahydrobenzene by method (ii.), p. 125.
,, ,, substituted dihydroresorcins by methods (i.) and (ii.), p. 127.
,, ,, substituted ketotetrahydrobenzenes, p 128.
,, ,, hexahydrobenzene dicarboxylic acid, p. 132.

Two examples have also been given of the passage of hydro-aromatic into aromatic bodies (p. 129), in which cases bromine is first added on at a double bond and then illuminated as hydrogen bromide. Other similar examples are the conversion of 3-chloro-1-methyl-$\Delta_{1:3}$-dihydrobenzene into metachlortoluene [1]



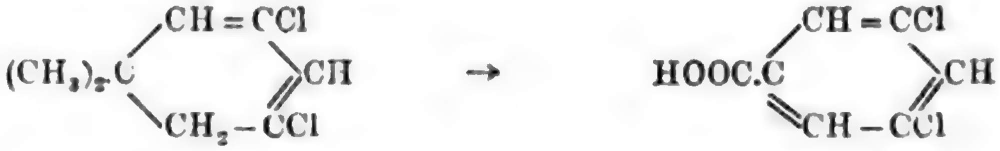
and of 3-chloro-1 : 5-dimethyl-$\Delta_{1:3}$-dihydrobenzene into chlorxylene.[2] From the author's experience it would seem that this action of bromine on derivatives of dihydrobenzene appears to be of a general nature, but the work is not sufficiently far advanced to permit of a more definite statement being made.

Bromine acts on hexahydrobenzene, giving rise to tetrabromobenzene.[3]

In some cases oxidising agents convert hydro-aromatic into aromatic bodies, as the three following examples show :—

1 : 3-Dimethyldihydrobenzene gives with nitric and sulphuric acids nitro-, dinitro-, and trinitro-xylanes.[4]

Nitric acid converts 3 : 5-dichloro-1 : 1-dimethyl-$\Delta_{2:4}$-dihydrobenzene into 3 : 5- dichlorobenzoic acid.[5]



1 : 4-Dihydroxyhexahydrobenzene (quinite) on oxidation with chromic acid gives quinone,[6] which, however, may itself be regarded as a hydro-aromatic substance.

In the following tables there will be found a comparison of some of the physical properties of benzene with those of the three typical hydro-aromatic hydrocarbons, dihydrobenzene, tetrahydrobenzene, and hexhydrobenzene, and of some open-chain hydrocarbons containing six carbon atoms :—[1]

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[1] Klages and Knoevenagel, *Ber.*, 1894, **27**, 3022.
[2] *Ibid.*, p. 3024.
[3] Zelinsky, *Ber.*, 1901, **34**, 2803.
[4] Wallach, *Annalen*, 1890, **258**, 319.
[5] Crossley and Le Sueur, *J.C.S.*, 1902, **81**, 831.
[6] *Ber.*, 1892, **25**, 1037.

—	Index of Refraction μ	d at 20°–4°	Mol. Vol. at 20°	$P\frac{\mu^2-1}{d(\mu^2+2)}$	
				For H_a	For D
Benzene, C_6H_6 . . .	1·4967	0·8799	88·65	25·93	26·13
Dihydrobenzene, C_6H_8 .	1·4699	0·8478	94·36	26·33	26·51
Tetrahydrobenzene, C_6H_{10} .	1·4435	0·8102	101·21	26·87	27·01
Hexahydrobenzene, C_6H_{12} .	1·4260	0·7900	107·20	27·56	27·66
Hexane, C_6H_{14} . . .	—	0·6603	130·25	29·70	29·84
Hexylene, C_6H_{12} . . .	—	0·6825	128·08	29·45	29·61
Diallyl, C_6H_{10} . . .	—	0·6880	119·18	28·77	28·96
Dipropargyl, C_6H_6 . .	—	0·8049	96·91	25·57	25·74

Dispersion of Hydrocarbons.

	Mol. refraction for H_γ-H_a		Dispersion
Dihydrobenzene . . .	27·511 – 26·145	=	1·366
Tetrahydrobenzene . . .	27·837 – 27·035	=	0·802
Hexahydrobenzene . . .	28·292 – 27·578	=	0·714

Stohmann and Langbein [2] give the following tabulated results :—

—	Heat of Combustion of 1-gram Molecule		Heat of Formation from Elements
	Constant Pressure	Constant Temperature	
Dihydrobenzene, C_6H_8 .	848·0 Cal.	846·8 Cal.	– 8·0 Cal.
Tetrahydrobenzene, C_6H_{10} .	892·0 „	890·5 „	+ 17·0 „
Hexahydrobenzene, C_6H_{12} .	933·2 „	931·5 „	+ 44·8 „
Normal hexane, C_6H_{14} .	991·2 „	—	+ 55·8 „

In comparing the chemical behaviour of these series it will perhaps be best to consider a few typical reagents and briefly discuss their action. Generally speaking, however, the properties of hydro-aromatic substances are the same as those of aliphatic bodies as modified by the presence of a ring and well illustrated by the hydrophthalic acids (p. 130).

Reagent	Aliphatic		Hydro-aromatic		Aromatic
	Saturated	Unsaturated	Saturated	Unsaturated	
Hydrogen	—	Addition	—	Addition	Does not add on readily to benzene and homologues; but is added readily to carboxylic acids.
„	Replaces halogen	—	Replaces halogen	—	Replaces halogen with great difficulty.
Chlorine	Substitution	Addition	Substitution	Addition	Substitution or addition, according to conditions.
Sulphuric Acid	—	—	—	—	Sulphonates.

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[1] Compare, Bruhl, *J. pr. Chem.* [2], **49**, 201, and *Ber.*, 1894, **27**, 1065; Fortey, *J.C.S.*, 1898, **73**, 932; Perkin, *Ber.*, 1902, **35**, 2102.

[2] *J. pr. Chem.* [2], **48**, 447.

Nitric acid.—It is generally stated that nitric acid has no action on the saturated paraffins, but it acts readily on unsaturated and aromatic bodies, producing oxidation in the first case and nitro-compounds in the second. This statement is, however, not strictly true as regards the paraffins. Much work has recently been done in this direction, for a detailed account of which the following, among other papers, may be consulted.[1]

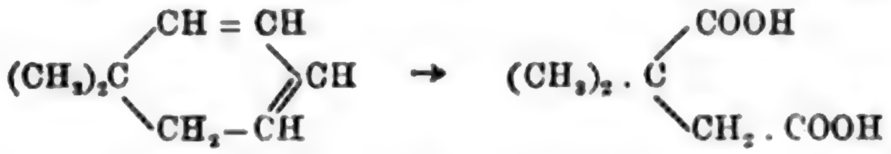
It is true that at ordinary temperatures the paraffins remain practically unacted on by nitric acid in any form, and that normal paraffins are slowly decomposed by fuming nitric acid on heating,[2] but the isoparaffins, *e.g.*, *iso*hexane, *iso*peptane, *iso*octane, and *diiso*butyl are very readily attacked by fuming nitric acid, a moderate yield of nitro-compound being obtained in each case.[3]

Hexahydrobenzene is only attacked when heated with fuming nitric acid, giving a dibasic acid, and its methyl derivative is directly broken down. Less concentrated nitric acid at high temperatures gives secondary nitro-compounds in addition to dibasic acids, and with methylhexahydrobenzene a tertiary nitro-derivative is obtained.

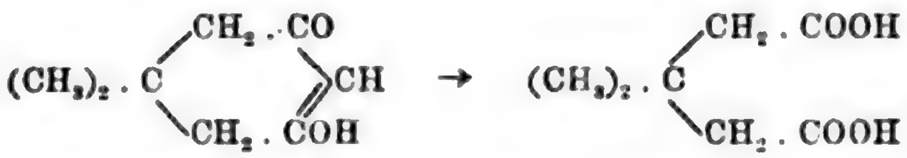
On hydro-aromatic substances containing double bonds nitric acid acts as an oxidising agent; in some cases nitro-derivatives are formed, which are usually aromatic bodies. Presumably nitric acid first removes hydrogen atoms by oxidation, and then nitrates the aromatic bodies so formed, *e.g.*, the production of nitro-xylenes from dimethyldihydrobenzene (see p. 134).

With aromatic substances nitric acid nitrates, and when oxidation does take place the side chain is the attackable point.

Oxidising agents.—These react with hydro-aromatic substances exactly as with aliphatic bodies, oxidation taking place at a double bond, *e.g.*, 1 : 1-dimethyl-$\Delta_{2:4}$-dihydrobenzene gives *αα*-dimethylsuccinic acid,[4]



and dimethyldihydroresorcin, which contains a double bond and also a carbonyl group, yields *ββ*-dimethylglutaric acid on oxidation. The



methyl groups, however, remain intact, whereas in an aromatic body the side chain is the attackable point and the ring remains unbroken.

Two other points may be worth mentioning in connection with dimethyldihydroresorcin. The hydroxyl group has the characteristics of a phenolic rather than an alcoholic group. The substance gives a violet coloration with ferric chloride, and caustic potash replaces the hydrogen atom of the hydroxyl group by potassium, giving a salt which is stable in aqueous solution, thus resembling potassium phenolate, and not potassium ethylate.

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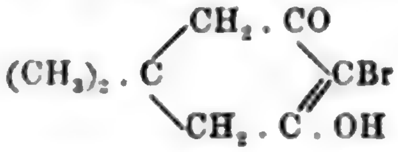
[1] Konowaloff, *Ber.*, 1892, **25**, R. 168; *J. Russ. Phys. Chem. Soc.*, 1899, **31**, 57, 254, 1027; and 1901, **33**, 48, 393; *Ber.*, 1899, **32**, 1445; Markownikoff, *Ber.*, 1897, **30**, 974, 1222; and 1899, **32**, 1441; 1902, **35**, 1584; also 386; *Annalen*, 1898, **301**, 201: Zelinsky, 1897, **30**, 389; Francis and Young, *J.C.S.*, 1898, **73**, 928; *Poni Cent. Blatt.*, 1902, ii. 16.

[2] Normal hexane and octane yield with dilute nitric acid secondary nitro compounds in nearly theoretical amount (Konowaloff, *Ber*, 1892, **25**, R. 168).

[3] Francis and Young (*ibid.*).

[4] Crossley and Le Sueur, *J.C.S.*, 1902, **81**, 836.

Dimethyldihydroresorcin readily gives a monobromo-derivative, in



which the bromine atom is very stable towards alkali,[1] thus resembling the bromine atom in an aromatic nucleus rather than in an aliphatic body.

Wave-length Tables of the Spectra of the Elements and Compounds.—Report of the Committee, consisting of Sir H. E. ROSCOE (*Chairman*), Dr. MARSHALL WATTS (*Secretary*), Sir J. N. LOCKYER, Professor J. DEWAR, Professor G. D. LIVEING, Professor A. SCHUSTER, Professor W. N. HARTLEY, Professor WOLCOTT GIBBS, *and* Captain Sir W. DE W. ABNEY.

INFRA-RED ARC SPECTRA OF THE ALKALIES.

Lehmann, 'Ann. d. Physik,' t. v. 1901, p. 633.

Wave-length	Intensity	Reduction to Vacuum		Oscillation Frequency
		λ +	1/–	
		POTASSIUM.		
7701·92	10	2·08	3·5	12981·7
7668·54	10	,,	3·6	13036·7
		RUBIDIUM.		
8513·26	4		3·2	11743·0
7950·46	8	2·15	3·4	12575·2
7805·98	10	2·11	3·5	12807·7
7753·58	6	2·10	,,	12893·8
7626·66	6	2·07	,,	13109·0
7406·19	4	2·01	3·7	13497·5
7277·01	4	1·97	,,	13738·1
		CÆSIUM.		
9211·86	6		3·0	10853·1
9171·38	6		,,	10900·0
8949·92	8		3·1	11171·1
8766·10	8		,,	11404·1
8527·72	18		3·2	11724·1
8082·02	6	2·19	3·4	12368·8
8019·62	6	2·17	,,	12465·7
7616·58	6	2·06	3·6	13125·7
7227·46	4	1·96	3·7	13833·1

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[1] Crossley, *J.C.S.*, 1899, **75**, 776; Vorländer, *Annalen*, 1902, **322**, 251.

THORIUM (ULTRA-VIOLET SPARK SPECTRUM).

Exner and Haschek, 'Sitzber. kaiserl. Akad. Wissensch. Wien,' cviii. 1899.
Lohse, Berl. Akad., 1897.

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
4740·70	2		1·30	5·8	21088·1
40·0	1n		,,	,,	091
32·9	1n		,,	,,	123
30·00	1		,,	,,	135·8
24·55	1		1·29	,,	160·2
23·93	1		,,	,,	163·0
23·60	1		,,	,,	164·5
20·17	1		,,	,,	179·9
18·79	1		,,	,,	186·2
15·60	1		,,	,,	200·4
12·57	1		,,	,,	215·0
08·27	1		,,	,,	233·4
06·41	1		,,	5·9	241·7
05·92	2		,,	,,	243·9
02·55	1		,,	,,	259·1
00·35	1		,,	,,	269·1
4695·05	1n		,,	,,	293·1
94·25	2		,,	,,	296·7
91·25	2		,,	,,	310·4
90 87	1		1·28	,,	312·1
89·33	1		,,	,,	319·1
85·65	1n		,,	,,	335·8
80·81	1		,,	,,	357·9
66·69	1		,,	,,	422·7
52·2	1n		,,	,,	490
51·76	2		1·27	,,	491·4
41·35	1		,,	,,	539·7
40·26	1		,,	,,	544·8
39·86	1		,,	,,	546·5
34·00	1		,,	6·0	573·6
31·94	2		,,	,,	583·2
27·8	1n		,,	,,	602·5
26 8	1n		,,	,,	607
25·24	1		,,	,,	611·7
24·22	1n		,,	,,	616·5
24·05	1n		,,	,,	620·0
19·67	3		,,	,,	640·6
12·71	1		,,	,,	673·2
12·06	1		,,	,,	676·3
10·00	1		,,	,,	686·0
09·53	2		,,	,,	688·2
06·69	1		,,	,,	701·5
05·42	1n		,,	,,	706·5
03·05	1		,,	,,	718·7
4599·55	1n		,,	,,	733·2
97·75	2b		,,	,,	743·8
95·66	1		,,	,,	753·6
94·69	1n		,,	,,	758·3
93·65	1n		,,	,,	763·2
93·48	1n		,,	,,	764·0
92 97	1n		,,	,,	766·4

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
4589·9	1n		1·27	6·0	21781
89·31	4		,,	,,	786·6
88·40	1		,,	,,	788·1
87·95	1n		,,	,,	790·2
87·47	1n		,,	,,	792·5
86·80	1n		,,	,,	795·7
86·44	1		,,	,,	797·4
84·55	1		,,	,,	806·4
83·9	1n		,,	,,	809·5
82·67	1n		,,	,,	815·3
81·78	1		,,	,,	819·6
81·42	1		,,	,,	821·3
79·5	1n		,,	,,	830·5
79·25	1n		,,	,,	831·7
75·61	1		,,	,,	849·0
73·90	1		,,	,,	857·2
69·20	1		,,	,,	879·7
66·85	1		,,	,,	890·9
64·35	1		,,	6·1	902·8
63·48	5		,,	,,	907·0
62·7	1n		,,	,,	911
55·82	8	4555·88	,,	,,	943·8
54·9	1b	54·31	,,	,,	947
54·08	1		,,	,,	952·2
53·25	1		,,	,,	956·2
52·5	1n		,,	,,	960
51·70	1		,,	,,	963·7
50·55	1		,,	,,	969·3
47·0	1n		,,	,,	986
46·3	1n		,,	,,	991
46·0	1n		,,	,,	991
44·70	2		,,	,,	997·6
43·42	1n		,,	,,	22003·7
42·55	1n		,,	,,	008·0
41·8	1n		,,	,,	012
40·60	2		,,	,,	017·4
39·00	1		,,	,,	025·2
37·26	2	37·24	,,	,,	033·6
36·63	1		,,	,,	036·7
34·30	2		,,	,,	048·5
33·50	3	33·55	,,	,,	051·9
32·47	2	32·54	,,	,,	056·9
31·90	2	31·89	,,	,,	059·7
29·67	1		,,	,,	070·6
29·06	1		,,	,,	073·5
28·6	1n		,,	,,	076
27·93	1		,,	,,	079·1
26·23	1		,,	,,	087·3
25·31	1		,,	,,	091·8
25·04	1		,,	,,	093·1
23·00	1		,,	,,	103·1
21·5	1n		,,	,,	111
21·2	1n		,,	,,	112
19·98	1		,,	,,	117·9
18·85	1		,,	,,	123·4

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
4518·40	2n		1·27	6·1	22125·6
17·24	1		,,	,,	136·1
16·20	2		,,	,,	139·4
13·91	1		,,	,,	147·6
12·70	2		,,	,,	153·5
10·73	5	10·78	,,	,,	163·3
08·9	1n		,,	,,	172
08·4	1n		,,	,,	175
00·21	2		,,	,,	215·1
4499·13	1n		,,	,,	220·4
96·53	2		,,	6·2	233·2
95·45	1n		,,	,,	238·4
95·13	1		,,	,,	240·1
93·57	1		,,	,,	247·9
92·45	1		,,	,,	253·5
92·02	1n		,,	,,	255·5
90·5	1n		,,	,,	263
89·7	1n		,,	,,	267
88·83	3		,,	,,	271·3
87·67	3	4487·59	,,	,,	277·1
86·80	2		,,	,,	281·4
85·99	1		,,	,,	285·4
84·44	1	83·23	,,	,,	293·1
81·85	1		,,	,,	306·0
81·37	1		,,	,,	308·4
81·02	2		,,	,,	310·1
79·36	1		,,	,,	318·4
77·1	1n	76·83	,,	,,	330
75·43	1		,,	,,	338·0
74·25	2	74·37	,,	,,	343·9
72·47	1		,,	,,	352·8
71·97	1		,,	,,	356·3
65·52	4	65·73	,,	,,	387·6
63·3	1n		,,	,,	399
61·91	2		,,	,,	405·7
61·23	2	61·43	,,	,,	408·8
57·65	1n		,,	,,	427·2
57·35	1n		,,	,,	428·6
56·83	1n		,,	,,	431·3
55·8	1n		,,	,,	436·5
55·20	1	55·19	,,	,,	439·5
54·62	1		,,	,,	442·4
51·23	1n		,,	,,	459·5
48·7	1n		,,	,,	472
48·00	2	48·14	,,	,,	475·8
45·13	1		,,	,,	490·3
43·30	1		,,	,,	499·6
42·05	1n		,,	,,	505·9
41·05	2	41·21	,,	,,	511·0
40·73	1		,,	,,	512·6
39·26	3	39·42	,,	,,	520·1
36·72	1	36·82	,,	,,	533·0
36·40	1	36·56	,,	,,	534·6
36·20	1		,,	,,	535·6
33·12	3	33·28	,,	,,	551·2

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
4429·40	1		1·27	6·3	22570·1
28·8	1n		,,	,,	573
27·85	1	27·95	,,	,,	578·0
26·18	2n	26·27	,,	,,	586·4
25·30	1n		,,	,,	591·0
24·10	1		,,	,,	597·2
22·95	1		,,	,,	603·0
22·0	1n		,,	,,	608
21·8	1n		,,	,,	609
19·18	1		,,	,,	622·3
18·84	1	18·97 Ce ?	,,	,,	624·1
16·40	2	16·48	,,	,,	636·6
14·8	1n	15·00	,,	,,	645
13·60	1		,,	,,	650·9
12·98	2	13·02 12·90	,,	,,	654·1
12·68	1		,,	,,	655·6
11·80	1		,,	,,	660·2
10·60	2	10·73	,,	,,	666·4
09·10	1		,,	,,	674·1
08·61	1		,,	,,	676·6
06·65	1n		,,	,,	686·7
05·95	1n		,,	,,	690·3
02·98	1n		,,	,,	705·6
01·87	1		,,	,,	711·1
00·56	1		,,	,,	718·1
4399·25	2	4399·39 Ce ?	,,	,,	724·8
98·10	2	98·16	,,	,,	730·8
96·67	1	96·69	,,	,,	738·2
95·09	2	95·14 Zr ?	,,	,,	746·3
93·28	1	93·31	,,	,,	755·7
91·30	8	91·29	,,	,,	766·0
88·59	1		,,	,,	780·0
87·93	5	87·98	,,	,,	783·5
87·27	1		,,	,,	786·4
86·35	1		,,	,,	791·7
84·3	1n		,,	,,	802
82·10	8	82·03	,,	,,	813·8
81·56	1		,,	,,	816·3
80·13	1n		,,	,,	824·0
79·75	1n		,,	,,	826·1
79·00	1		,,	,,	830·0
77·50	2	77·50	,,	,,	837·8
75·77	1		,,	,,	846·8
74·96	2	74·98 Yt ?	,,	,,	851·1
74·08	2	74·15	,,	,,	855·6
69·50	2	69·48	,,	,,	879·6
66·08	1		,,	6·4	897·4
64·5	1n		,,	,,	906
62·55	1		,,	,,	916·0
61·96	1		,,	,,	919·1
61·50	2	61·52	,,	,,	921·5
59·00	1		,,	,,	934·6
58·70	1		,,	,,	936·2
57·79	1		,,	,,	941·0

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}-$	
4355·50	2	55·54	1·27	6·4	22953·1
53·55	1	53·64 Ce ?	,,	,,	963·3
52·87	1	52·92 Ce ?	,,	,,	966·9
51·00	1		,,	,,	975·8
49·57	3n		,,	,,	984·4
47·36	1	47·46	,,	,,	996·0
45·22	1		,,	,,	23007·4
44·50	2	44·60	,,	,,	011·2
44·16	2	44·21	,,	,,	013·0
43·79	1	43·93	,,	,,	015·0
42·45	2	42·50 Zr ?	,,	,,	022·1
41·22	2	41·30 Zr ?	,,	,,	028·6
37·55	2	37·64	,,	,,	048·1
36·7	1n		,,	,,	053
35·89	3	35·97	,,	,,	056·9
35·46	1		,,	,,	059·2
34·11	2	34·22	,,	,,	066·4
32·09	2	32·18	,,	,,	076·5
31·4	1b		,,	,,	081
29·65	1	29·78 Zr ?	,,	,,	090·2
28·86	1	28·95	,,	,,	094·4
27·30	1		,,	,,	102·7
23·1	1n		,,	,,	125
22·9	1n		,,	,,	126
20·77	2	20·84	,,	,,	137·6
20·31	2	20·36	,,	,,	140·1
19·28	1	19·82 19·42	,,	,,	147·6
18·47	1	18·61	,,	,,	150·0
16·15	1		,,	,,	162·4
15·86	1		,,	,,	164·0
15·52	1		,,	,,	165·8
14·22	1		,,	,,	172·8
13·53	1		,,	,,	176·5
13·17	1		,,	,,	178·4
10·90	1n		,,	,,	190·6
10·19	4	10·23	,,	,,	194·4
08·42	1		,,	6·5	203·9
07·40	1		,,	,,	209·3
06·57	2	06·58	,,	,,	213·8
05·65	1n		,,	,,	218·8
02·2	1b	02·74 Ca ?	,,	,,	237
00·98	1		,,	,,	246·0
99·66	1		,,	,,	251·1
99·01	1	4298·79 Zr ?	,,	,,	254·7
97·53	1		,,	,,	262·7
97·11	1		,,	,,	265·0
96·83	1		,,	,,	266·5
95·25	3	95·27	,,	,,	275·0
91·60	1		,,	,,	294·8
90·6	1n		,,	,,	300
88·23	2	88·20	,,	,,	313·1
87·9	1n		,,	,,	315
86·90	1		,,	,,	320·4
86·38	1	86·39	,,	,,	323·2

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	1/λ −	
4385·35	1n		1·27	6·5	23328·8
85·15	2	85·16	„	„	329·9
83·70	2	83·67	„	„	337·8
82·20	4	82·19	„	„	346·0
81·63	2	81·61	„	„	349·1
81·23	2	81·25	„	„	351·2
80·43	1		„	„	355·6
77·49	2	77·47	„	„	371·7
77·13	1	} 77·04	„	„	373·6
76·97	1				374·5
74·51	1		„	„	388·0
74·19	2	74·17 La ?	„	„	389·7
73·54	3	73·51	„	„	393·3
71·26	1	71·26	„	„	405·7
70·49	1	70·50	„	„	410·0
63·50	1	63·54	„	„	448·4
62·9	1n		„	„	452
56·25	1	56·34 Ce ?	„	„	488·3
54·60	1		„	„	497·5
54·09	1		„	„	500·3
54·00	1		„	„	500·8
53·66	1		„	6·6	502·6
53·35	1		„	„	504·3
50·50	2	50·57	„	„	520·1
49·80	2	49·91	„	„	523·9
48·10	3	48·23	„	„	533·3
47·73	1		„	„	535·4
4246·56	1		„	„	541·9
45·63	1		„	„	547·0
44·99	1		„	„	550·6
44·05	2	44·17	„	„	555·8
42·95	1n		„	„	561·9
42·52	1n	40·84 U ?	„	„	564·3
39·13	1		„	„	583·1
37·25	1n		„	„	593·6
35·12	1		„	„	605·5
34·44	1		„	„	609·3
33·41	1	33·51	„	„	615·0
29·58	2	29·73	„	„	636·4
27·82	1	26·98 Ca ?	„	„	646·3
26·0	1n		„	„	656
24·75	1		„	„	663·4
24·37	1		„	„	665·5
23·9	1n		„	„	668
22·32	1		„	„	676·6
20·23	2	20·27	„	„	688·8
19·54	1		„	„	692·7
18·69	1		„	„	697·4
18·34	1		„	„	699·4
17·35	1		„	„	705·0
16·19	1		„	„	711·5
14·73	1	15·74 Sr ?	„	„	719·7
14·15	1		„	„	722·9
13·28	1		„	„	727·9
11·67	2	11·72	„	„	736·2

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$ −	
4209·01	5	09·07	1·27	6·6	23752·0
06·83	1	06·93	,,	,,	764·3
02·03	2	02·11	,,	,,	791·4
4199·18	1		,,	6·7	807·5
97·24	1		,,	,,	818·5
96·02	2n	4195·97	,,	,,	825·4
95·75	2	95·73	,,	,,	826·9
94·27	1		,,	,,	835·3
93·15	1		,,	,,	841·7
92·03	1n	91·97 Zr ?	,,	,,	848·1
88·75	1		,,	,,	866·8
84·95	1n	84·87	,,	,,	888·4
84·48	1	84·29	,,	,,	891·1
83·76	1	83·57	,,	,,	895·2
82·15	2	82·21	,,	,,	904·4
		81·18			
80·15	2		,,	,,	915·9
79·86	2	79·98 Zr ? 79·77	,,	,,	917·5
78·20	3	78·16	,,	,,	927·0
76·55	1n		,,	,,	936·5
74·65	1n		,,	,,	937·4
74·15	1n		,,	,,	940·3
73·7	1n		,,	,,	953
71·52	2	71·56	,,	,,	955·3
71·00	1	71·00	,,	,,	968·4
70·65	2	70·67	,,	,,	970·4
68·81	2	68·81	,,	,,	981·0
67·45	1n		,,	,,	988·8
66·7	1n		,,	,,	993
65·92	1		,,	,,	997·6
65·25	1	65·24	,,	,,	24001·4
64·43	1	64·45	,,	,,	006·2
63·84	2	63·86	,,	,,	009·8
63·37	1		,,	,,	012·3
62·87	2	62·88	,,	,,	015·2
62·10	1		,,	,,	019·6
61·73	1		,,	,,	021·2
60·9	1n		,,	,,	027
59·82	2	59·76	,,	,,	032·8
57·67	1		,,	,,	045·2
57·20	1		,,	,,	048·0
56·69	2	4156·67	,,	,,	050·9
56·35	1	56·39 Zr ?	,,	,,	052·3
55·51	1		,,	,,	057·7
51·6	1		,,	,,	080
50·17	2	50·11 Ce ?	,,	,,	088·7
48·5	1n		,,	6·8	098
48·35	2	48·31	,,	,,	099·1
42·87	2	42·80	,,	,,	131·1
42·63	2	42·63 Ce ?	,,	,,	132·5
41·82	3	41·75	,,	,,	137·2
40·42	4	40·35	,,	,,	145·4
38·97	1		,,	,,	153·8
36·53	2	36·51	,,	,,	168·0

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
4134·27	2	34·21	1·27	6·8	24181·3
32·95	3	32·91	,,	,,	189·0
31·60	2	31·63	,,	,,	196·9
30·83	1		,,	,,	201·4
30·15	1n		,,	,,	205·5
29·15	1n		,,	,,	211·2
27·60	1		,,	,,	220·4
24·79	2	24·76 Ce ?	,,	,,	236·9
23·72	1	23·70	,,	,,	243·1
23·17	1		,,	,,	246·3
22·85	1	22·83	,,	,,	248·9
22·06	1	22·02	,,	,,	253·5
16·91	5	16·83	,,	,,	283·3
15·85	1		,,	,,	289·5
14·3	1n		,,	,,	299
13·77	1	13·71	,,	,,	299·8
12·95	1	12·92 Zr ?	,,	,,	306·6
12·52	1	12·43	,,	,,	309·2
11·09	1	10·98	,,	,,	315·6
10·72	2	10·70	,,	,,	319·8
		10·31	,,	,,	
08·61	3	08·55	,,	,,	332·3
08·01	1	07·93	,,	,,	335·9
07·58	1	07·50 Ce ?	,,	,,	338·4
06·6	1n	06·03	,,	,,	344
05·55	2	05·46	,,	,,	350·5
04·60	2	04·47	,,	,,	355·1
03·9	1n	03·75	,,	,,	359
		03·35	,,	,,	
01·60	1	00·97 Di ?	,,	,,	373·9
01·08	2	00·50	,,	,,	376·0
00·57	1		,,	,,	380·0
4099·13	2	4099·05	,,	6·9	388·5
97·93	1	97·85	,,	,,	395·7
97·52	1	97·45	,,	,,	398·1
94·99	3	94·90	,,	,,	413·2
93·60	1n	93·57	,,	,,	420·5
91·7	1n		,,	,,	433
91·53	1		,,	,,	433·8
86·71	3	86·88 La ?	,,	,,	462·6
86·02	1	86·95 Zr ?	,,	,,	463·7
85·22	4	85·21	,,	,,	471·6
83·60	1		,,	,,	481·3
82·49	1	82·43 Zr ?	,,	,,	487·9
82·10	1	82·03 Zr ?	,,	,,	490·3
81·23	1		,,	,,	495·5
80·50	1		,,	,,	499·9
80·12	1		,,	,,	502·2
79·77	1		,,	,,	504·3
79·35	1		,,	,,	506·8
		77·89 Sr ?	,,	,,	
74·90	1		,,	,,	533·6
73·92	1		,,	,,	539·5
73·15	1	73·14	,,	,,	544·1
70·95	1		,,	,,	557·4

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
4069·40	4	69·39	1·27	6·9	24566·7
68·15	1n		"	"	574·3
67·78	1		"	"	576·6
66·3	1n		"	"	585·5
65·90	1		"	"	587·9
65·46	1		"	"	590·6
64·9	1n		"	"	594
64·50	1		"	"	596·4
63·91	1		"	"	599·9
63·59	1		"	"	601·9
60·05	1		"	"	623·3
59·45	1		"	"	626·9
57·99	1		"	"	635·8
57·52	1		"	"	638·7
57·23	1n		"	"	640·4
55·43	1		"	"	651·4
55·00	1		"	"	654·0
53·68	1n		"	"	662·0
52·65	1n		"	"	668·3
51·3	1n		"	7·0	676
51·1	1n		"	"	678
50·02	1		"	"	684·1
49 02	3n	49·02	"	"	690·2
48·60	1	48·61	"	"	692·9
48·18	1	48·22	"	"	695·5
45·85	1		"	"	719·7
43 2	1n	43·21	"	"	726
41·36	2	41·32	"	"	737·1
40·45	1		"	"	742·7
39·53	1		"	"	748·9
37·40	1n		"	"	761·4
36·71	2	36·70	"	"	765·6
36·22	1		"	"	768·7
35·02	1		"	"	776·0
34·36	2		"	"	780·1
32·69	2	34·47	"	"	790·3
31·47	1n	32·74	"	"	797·8
31·25	1		"	"	799·2
31·00	1		"	"	800·7
30·45	1n		"	"	804·1
29·5	1n		"	"	810
29·18	1		"	"	811·9
28·83	1	28·94	"	"	814·1
27·82	1		"	"	820·4
27·48	1		"	"	822·4
26·30	1	26·42	"	"	829·7
25·78	2	25·85	"	"	832·9
24·63	1		"	"	841·0
23·70	1		"	"	845·5
23·25	1		"	"	848·5
22·23	1	22·30 Ce ?	"	"	854·8
20·22	1		"	"	867·2
19·30	10		"	"	872·9
17·25	1		"	"	885·6
16·45	1		"	"	890·6

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
4015·27	1n		1·27	7·0	24897·9
14·66	1		"	"	901·7
13·45	1		"	"	909·2
12·67	1		"	"	914·1
11·95	2		"	"	918·5
11·17	1		"	"	923·4
10·65	1n		"	"	926·6
09·70	1n		"	"	932·1
09·22	1		"	"	935·5
08·35	1		"	"	940·9
07·68	3		"	"	945·1
06·51	2		"	"	952·4
05·69	3		"	"	957·4
03·49	3		"	7·1	971·1
03·21	2		"	"	972·3
01·88	1		"	"	981·1
01·22	1		"	"	991·0
00·10	1		"	"	992·3
3998·01	3		"	"	999·7
97·60	1		"	"	25007·9
96·20	2		"	"	016·7
94·70	2		"	"	026·1
93·86	1		"	"	031·3
92·46	1		"	"	040·1
92·21	1		"	"	041·7
91·80	1n		"	"	044·3
90·72	1n		"	"	051·0
90·25	1		"	"	054·0
88·99	1		"	"	061·9
88·71	1		"	"	063·5
88·17	3		"	"	067·0
87·88	1		"	"	068·9
87·35	1		"	"	072·2
87·21	1		"	"	072·6
86·81	1		"	"	075·6
86·26	1		"	"	079·0
85·55	1		"	"	083·5
84·76	1		"	"	088·5
84·50	1		"	"	090·2
82·36	1		"	"	103·6
82·23	1		"	"	104·0
81·70	1		"	"	107·8
81·28	3		"	"	110·5
80·90	2		"	"	112·9
80·26	1		"	"	116·9
79·20	2		"	"	123·6
77·99	1		"	"	131·2
76·56	2		"	"	140·3
75·36	1		"	"	147·9
74·38	1		"	"	154·0
72·30	1		"	"	167·2
70·00	1		"	"	181·8
69·70	1n		"	"	183·7
69·50	1		"	"	185·0
69·15	1		"	"	187·2

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
3967·52	1n		1·27	7·1	25197·6
67·37	1		,,	,,	198·5
67·10	1		,,	,,	200·2
66·9	1n		,,	,,	201·5
65·00	1		,,	,,	212·6
63·65	2		,,	,,	222·2
63·33	2		,,	,,	224·2
62·49	2		,,	,,	229·5
61·07	1		,,	,,	238·6
60·50	2		,,	,,	242·2
59·38	1n		,,	,,	249·4
58·30	1		,,	,,	256·3
56·75	3		,,	,,	266·2
55·38	1n		,,	7·2	274·8
53·58	1n		,,	,,	287·3
52·60	1		,,	,,	292·6
51·66	3		,,	,,	298·6
51·25	1		,,	,,	301·2
50·53	2		,,	,,	305·9
49·06	2r		,,	,,	315·3
47·80	1n		,,	,,	327·4
47·48	1n		,,	,,	325·4
47·3	1n		,,	,,	327
46·30	2		,,	,,	333·0
45·96	1		,,	,,	335·2
45·63	2		,,	,,	337·3
43·81	2		,,	,,	349·0
43·47	2n		,,	,,	351·2
42·95	1n		,,	,,	354·5
42·75	1		,,	,,	355·7
42·20	1		,,	,,	359·3
41·48	1		,,	,,	364·0
40·49	1		,,	,,	370·4
39·88	1		,,	,,	374·3
38·86	2		,,	,,	370·9
38·01	2		,,	,,	386·3
37·14	2		,,	,,	391·9
36·45	1		,,	,,	396·4
36·07	1		,,	,,	398·8
35·74	1		,,	,,	401·0
35·32	1		,,	,,	403·7
34·90	1		,,	,,	406·4
33·65	1		,,	,,	414·5
33·00	1		,,	,,	418·7
32·35	1		,,	,,	422·9
32·10	1		,,	,,	424·5
31·35	1n		,,	,,	429·6
30·43	1		,,	,,	435·3
29·74	3		,,	,,	439·8
27·54	2		,,	,,	454·0
27·24	2		,,	,,	456·0
26·80	1		,,	,,	458·8
25·19	2n		,,	,,	469·3
22·34	1		,,	,,	487·8
20·11	1		,,	,,	500·3

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ –	
3918·62	1		1·27	7·2	25111·4
18·13	1		,,	,,	515·2
16·90	3		,,	,,	523·2
15·92	1		,,	,,	529·6
14·6	1n		,,	,,	538
13·95	1		,,	,,	542·4
13·15	2		,,	,,	547·6
12·41	2		,,	,,	553·5
11·45	1		,,	,,	558·3
08·6	1n		,,	7·3	577
08·03	1		,,	,,	581·0
07·48	1n		,,	,,	584·7
06·95	1n		,,	,,	588·1
06·13	1n		,,	,,	593·5
05·29	3r		,,	,,	599·0
04·21	2		,,	,,	606·1
02·60	1		,,	,,	616·6
02·25	1		,,	,,	618·9
01·3	1n		,,	,,	625
00·99	3		,,	,,	627·2
00·25	1		,,	,,	631·6
3899·1	1n		,,	,,	640
98·95	1		,,	,,	640·6
98·60	1		,,	,,	642·9
95·55	1		,,	,,	663·0
95·02	1		,,	,,	666·5
94·53	1		,,	,,	669·7
93·55	1		,,	,,	676·2
93·20	2		,,	,,	678·5
92·42	2		,,	,,	683·7
91·18	2		,,	,,	691·9
90·49	1		,,	,,	696·4
87·55	1		,,	,,	715·8
87·08	1		,,	,,	719·0
86·12	1		,,	,,	723·3
85·87	1n		,,	,,	727·0
84·96	2		,,	,,	733·0
84·67	1		,,	,,	734·9
72·87	3 CN		,,	,,	813·3
72·45	1n		,,	,,	816·1
69·77	1		,,	,,	834·0
69·50	1		,,	,,	835·8
67·46	1		,,	,,	849·4
67·00	1n		,,	,,	852·5
65·20	1*		,,	,,	864·6
63·51	3 CN		,,	,,	875·9
62·50	1		,,	,,	882·7
59·98	3n		,,	,,	899·6
54·61	3		,,	,,	935·7
53·60	1		,,	,,	942·5
53·10	1		,,	,,	945·8
51·72	1n		,,	,,	959·1
46·40	1		,,	,,	991·0
45·17	1		,,	,,	999·3
43·10	3		,,	,,	26013·3

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
3839·90	3		1·27	7·3	26035·0
38·92	1		,,	,,	041·7
38·01	2		,,	,,	047·9
36·65	2 CN		,,	,,	057·1
34·75	1		,,	,,	070·0
32·97	1		,,	,,	082·1
32·59	1		,,	,,	084·7
31·90	3		,,	,,	089·4
29·53	2		,,	,,	105·6
28·58	2 CN		,,	,,	112·0
28·30	2 CN		,,	,,	114·0
27·11	2		,,	,,	132·1
25·80	1		,,	,,	131·0
25·21	2		,,	,,	135·0
24·92	1		,,	,,	137·0
24 52	1		,,	,,	139·8
23·74	1		,,	,,	145·1
23·50	1		,,	,,	146·7
22·33	3		,,	,,	154·7
21·94	1		,,	,,	157·4
21·57	3		,,	,,	159·9
20·95	1		,,	,,	164·2
20 13	1n		,,	,,	169·8
19·46	2n		,,	,,	174·4
19·2	1n		,,	,,	176
18·81	1		,,	,,	178·9
17·86	2n		,,	7·4	185·3
17·51	2		,,	,,	187·7
16·73	1		,,	,,	193·0
15·71	1		,,	,,	199·0
15·22	1		,,	,,	203·4
15·02	1		,,	,,	204·7
14·73	2		,,	,,	206·8
13·85	1		,,	,,	212·8
13·21	4		,,	,,	217·2
12·30	2		,,	,,	223·5
11·55	2		,,	,,	228·6
11·20	1		,,	,,	231·1
10·75	1n		,,	,,	234·2
10·00	3		,,	,,	239·3
09·25	1		,,	,,	244·5
08·84	1n		,,	,,	247·3
08·30	1n		,,	,,	251·0
08·04	3		,,	,,	252·8
06·96	1		,,	,,	260·3
05·95	2		,,	,,	267·2
05·55	1		,,	,,	270·0
05·18	1		,,	,,	272·5
04·85	2		,,	,,	274·8
04·3	1n		,,	,,	279
04·2	1n		,,	,,	279
03·25	2		,,	,,	283·8
02·93	1		,,	,,	288·0
02·31	1		,,	,,	292·3
02·10	1		,,	,,	293·8

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{\;}{\lambda}$ −	
3801·75	1n		1·27	7·4	26296·4
01·50	2		,,	,,	298·0
00·80	2		,,	,,	301·9
00·53	1		,,	,,	304·8
00·20	1		,,	,,	307·0
3799·79	1		,,	,,	309·8
99·36	1		,,	,,	312·8
98·70	1n Fe		,,	,,	317·4
98·25	1n		,,	,,	320·5
98·1	1n		,,	,,	321
97·66	2		,,	,,	324·6
97·10	1		,,	,,	328·5
96·33	1		,,	,,	333·8
95·90	1		,,	,,	336·8
95·53	2		,,	,,	339·4
94·50	2		,,	,,	346·5
94·30	2		,,	,,	347·9
93·92	1		,,	,,	350·6
93·65	1		,,	,,	352·4
93·14	1		,,	,,	353·5
92·80	1		,,	,,	358·35
92·52	1		,,	,,	360·3
92·15	1n		,,	,,	362·9
91·50	2		,,	,,	367·4
90·99	1		,,	,,	370·9
90·67	1		,,	,,	373·1
90·2	2n		,,	,,	378
89·29	3		,,	,,	382·8
88·54	1		,,	,,	387·0
87·65	1		,,	,,	394·0
87·34	1		,,	,,	396·4
87·04	1		,,	,,	402·3
86·12	1		,,	,,	405·1
85·80	3		,,	,,	407·1
85·50	1n		,,	,,	409·2
83·95	2b		,,	,,	420·0
83·48	2		,,	,,	423·3
83·27	3		,,	,,	424·8
82·35	1n		,,	,,	431·2
81·83	1		,,	,,	434·8
81·05	1n		,,	,,	440·3
80·65	1		,,	,,	443·1
79·95	1		,,	,,	448·0
78·93	1		,,	,,	455·1
78·06	1		,,	,,	461·2
77·50	1		,,	,,	465·1
77·27	1		,,	,,	466·7
76·10	2r		,,	,,	474·9
75·47	1		,,	,,	479·4
74·40	2n		,,	,,	486·9
73·94	3		,,	,,	490·1
73·23	2n		,,	7·5	495·0
72·41	2		,,	,,	500·7
71·96	1		,,	,,	503·9
71·55	1		,,	,,	506·8

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
3770·4	1n		1·27	7·5	26515
70·25	1n		,,	,,	515·9
68·62	1		,,	,,	527·4
68·05	3		,,	,,	531·4
67·39	1		,,	,,	536·2
66·52	1n		,,	,,	542·2
65 70	1		,,	,,	548·0
65·43	2		,,	,,	549·9
64·9	1n		,,	,,	554
64·48	1		,,	,,	556·6
64·26	1		,,	,,	558·1
63·75	1		,,	,,	561·7
63·49	1		,,	,,	563·7
63·04	4		,,	,,	566·7
62·50	1n		,,	,,	570·6
61·28	3n		,,	,,	579·2
60·48	2		,,	,,	581·9
59·46	2		,,	,,	592·1
58·95	1		,,	,,	595·8
57·88	1		,,	,,	603·2
57·44	1		,,	,,	605·4
56·9	1n		,,	,,	610
56·46	1		,,	,,	613·3
56·05	1n		,,	,,	616·2
55·55	1n		,,	,,	619·7
55·37	1n		,,	,,	621·0
54·75	2		,,	,,	625·4
52·73	6		,,	,,	639·8
51·91	1		,,	,,	645·6
50·82	1		,,	,,	653·3
50·30	1		,,	,,	657·0
49·17	1		,,	,,	665·1
48·45	2		,,	,,	670·2
47·73	3		,,	,,	675·3
46·68	1		,,	,,	682·8
46·15	3		,,	,,	686·5
44·89	2		,,	,,	695·6
43·71	2		,,	,,	704·0
43·15	1		,,	,,	708·0
42·45	1		,,	,,	712·9
41·40	6		,,	,,	720·5
41·03	2		,,	,,	723·1
40·6	1n		,,	,,	726
39·95	1		,,	,,	730·8
39·02	4		,,	,,	737·5
37·37	1		,,	,,	749·3
37·10	1		,,	,,	751·2
35·70	1		,,	,,	761·2
35·05	1 Fe?		,,	,,	765·9
34·77	2		,,	,,	767·9
32·85	1n		,,	,,	781·7
31·60	2		,,	,,	790·6
30·96	4		,,	,,	795·3
28·32	1		,,	7·6	814·1
28·11	1		,,	,,	815·6

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
3726 89	3		1·27	7·6	26824·5
26·40	1n		,,	,,	827·9
26 02	1		,,	,,	830 7
24·93	2		,,	,,	838·5
24·70	1		,,	,,	840·2
23·85	2		,,	,,	846·3
23·46	2		,,	,,	849·1
22 35	3		,,	,,	857·1
22·01	3		,,	,,	859·6
21·55	1n		,,	,,	862·9
20·90	1n		,,	,,	867·6
20·52	3		,,	,,	870·4
20·18	3		,,	,,	872·8
19·90	1		,,	,,	874·8
19·63	1		,,	,,	876·8
18 85	1		,,	,,	882·4
18·36	2		,,	,,	886·0
18·00	2		,,	,,	888·4
16·98	1		,,	,,	896·0
16·42	1		,,	,,	900·0
14·53	1n		,,	,,	913·7
12·71	2		,,	,,	926·9
11·95	1n		,,	,,	932·4
11·50	3		,,	,,	935·7
10·75	1		,,	,,	941·1
09·82	1		,,	,,	947·9
08·90	2		,,	,,	954·6
07·60	1		,,	,,	964·0
07·16	1		,,	,,	967·2
06·91	2		,,	,,	976·8
06·15	1n		,,	,,	975·6
05·16	1		,,	,,	981·8
04·16	4		,,	,,	989·0
03·04	2		,,	,,	997·2
02·26	1		,,	,,	27002·9
00·95	3		,,	,,	012·5
00·50	2n		,,	,,	015·8
00·1	1n		,,	,,	019
3698·95	1		,,	,,	027·1
98·47	2		,,	,,	030·6
98·30	1n		,,	,,	031·8
97·21	2		,,	,,	039·8
96·82	2		,,	,,	042·7
96·15	3		,,	,,	047·6
95·25	1n		,,	,,	054·2
95·05	1n		,,	,,	055·6
94·08	3		,,	,,	062·8
92·65	6r		,,	,,	073·2
92·24	1		,,	,,	077·3
90·67	3		,,	,,	087·7
90·27	2		,,	,,	090·6
88·93	4		,,	,,	100·5
88·40	1		,,	,,	104·3
87·80	2n		,,	,,	108·8
87·13	1		,,	,,	113·7

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
3686·03	1		1·27	7·6	27121·8
84·10	1		"	"	136·1
83·50	1		"	7·7	140·8
83·01	1		"	"	144·0
82·52	1		"	"	147·6
82·06	2		"	"	151·0
81·38	2		"	"	156·0
80·72	1		"	"	160·9
79·89	5		"	"	167·0
78·96	1		"	"	173·9
78·19	4		"	"	179·6
78·0	1n		"	"	181
76·88	1		"	"	189·3
75·72	4		"	"	197·9
73·97	3		"	"	210·8
73·45	2		"	"	214·6
73·15	1		"	"	216·9
71·72	1 M ?		"	"	227·5
71·38	1		"	"	230·0
70·80	1		"	"	234·3
70·21	3		"	"	238·7
69·56	1		"	"	243·5
68·31	1		"	"	252·8
66·53	1		"	"	266·0
65·90	1		"	"	270·7
65·62	1		"	"	272·8
65·33	1		"	"	275·0
63·88	4		"	"	285·8
63·32	2		"	"	289·9
62·80	1		"	"	293·8
62·36	1		"	"	297·1
61·65	6n		"	"	302·4
60·28	1		"	"	312·6
59·66	6n		"	"	317·2
58·32	2n		"	"	327·2
58·20	3		"	"	328·1
57·70	1		"	"	331·9
56·35	2		"	"	341·9
55·2	1n		"	"	351
54·74	1		"	"	354·0
53·72	1		"	"	361·7
52·69	2		"	"	369·4
52·31	4		"	"	372·2
51·72	1		"	"	376·7
23·17	1		"	7·8	592·3
22·87	1		"	"	594·6
22·45	1		"	"	597·8
21 25	4		"	"	606·9
20·52	3		"	"	615·2
19·85	1		"	"	617·9
19·50	1		"	"	620·3
18·87	1n		"	"	625·1
18·48	1n		"	"	628·1
17·88	1		"	"	632·7
17·22	5		"	"	637·7

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$ −	
3616·85	1		1·27	7·8	27641·6
15·26	3		,,	,,	652·7
14·16	3		,,	,,	661·1
13·91	1		,,	,,	663·1
12·57	1		,,	,,	673·3
12·27	1		,,	,,	675·6
10·94	2		,,	,,	685·8
10·55	2		,,	,,	688·8
10·20	2n		,,	,,	691·5
09·60	4		,,	,,	696·1
09·34	1		,,	,,	698·1
08·48	1		,,	,,	704·7
08·07	1		,,	,,	707·9
07·52	1		,,	,,	712·1
06·87	1n		,,	,,	717·1
06·32	2		,,	,,	721·3
05·78	1		,,	,,	725·4
04·17	2		,,	,,	737·8
03·76	1		,,	,,	741·0
03·49	2		,,	,,	743·1
03·32	3		,,	,,	744·4
02·63	1n		,,	,,	749·7
02·14	1		,,	,,	753·5
01·20	7		,,	,,	760·7
3599·77	1		,,	,,	771·7
99·45	1		,,	,,	774·2
99·13	1		,,	,,	777·7
98·24	1n		,,	,,	783·5
97·00	1		,,	,,	793·1
95·40	2		,,	,,	805·5
94·20	1n		,,	7·9	814·7
93·96	2		,,	,,	816·6
92·92	2		,,	,,	824·6
92·60	1		,,	,,	827·2
91·16	3n		,,	,,	838·2
89·47	2		,,	,,	851·4
89·22	1		,,	,,	853·3
88·35	2		,,	,,	860·0
85·91	2		,,	,,	879·0
85·16	2		,,	,,	884·9
83·16	2		,,	,,	899·6
82·15	2		,,	,,	907·5
81·33	1		,,	,,	914·7
80·36	2		,,	,,	922·2
79·45	3		,,	,,	929·3
78·27	1		,,	,,	938·5
77·34	1		,,	,,	941·8
76·68	1		,,	,,	951·0
75·43	4		,,	,,	960·7
73·64	1		,,	,,	974·7
73·35	2		,,	,,	977·0
72·52	4		,,	,,	983·5
71·70	2		,,	,,	990·0
70·03	1		,,	,,	28003·1
69·75	1		,,	,,	005·3

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
3568·10	1		1·27	7·9	28018·2
67·81	1		"	"	020·5
67·40			"	"	023·7
67·16			"	"	025·6
66·3	1b		"	"	032
65·24	1		"	"	040·7
64·83	2		"	"	043·9
64·1	2b		"	"	050
63·48	1		"	"	054·5
60·99	1		"	"	074·2
60·08	2		"	"	081·4
59·55	3		"	"	085·5
57·56	2		"	"	101·2
56·45	1		"	"	110·0
55·9	1b		"	"	114
55·21	2		"	"	119·9
54·45	1		"	"	125·9
53·52	1n		"	"	133·2
53·23	2		"	"	135·5
52·03	1		"	"	145·0
51·55	1		"	8·0	148·7
50·89	1		"	"	154·0
50·47	2		"	"	157·3
49·91	2		"	"	161·7
47·60	1		"	"	180·1
46·41	1		"	"	189·5
45·48	3n*		"	"	196·9
45·19	1		"	"	199·2
44·55	1n		"	"	204·3
44·2	1n		"	"	207
42·80	1		"	"	218·2
42·40	1		"	"	221·4
42·14	1		"	"	223 5
41·80	2		"	"	226·2
39·75	3		"	"	242·6
39·47	2		"	"	244 8
38·90	10		"	"	249·4
38·37	1		"	"	253 6
37·30	3		"	"	262·1
36·80	1		"	"	266·1
36·2	1n		"	"	271
35·5	1b		"	"	276·5
33·85	1		"	"	288·7
33·12	3n		"	"	295·6
32·08	2		"	"	303·9
31·8	1n		"	"	306
29·06	5		"	"	328·2
28·3	1b		"	"	334
27·5	1b		"	"	341
26·89	1		"	"	345·6
26·40	1		"	"	349·5
25 80	1		"	"	354·4
25·30	1		"	"	358·4
23·73	1		"	"	371·0
22·09	3		"	"	384·2

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
3520·85	1		1·27	8·0	28394·2
19·88	2		,,	,,	402·1
19·02	1		,,	,,	409·0
18·83	1		,,	,,	410·5
16·96	3		,,	,,	425·6
16·50	2		,,	8·1	429·2
15·89	1		,,	,,	434·2
15·13	1		,,	,,	440·3
14·70	2		,,	,,	443·8
13·80	1		,,	,,	450·3
13·41	1		,,	,,	454·3
12·29	2		,,	,,	463·3
11·82	6r		,,	,,	467·2
10·91	1		,,	,,	474·5
10·72	1		,,	,,	476·1
09·33	1		,,	,,	487·3
07·72	10		,,	,,	498·2
07·00	1		,,	,,	500·7
05·62	2		,,	,,	517·7
04·20	1		,,	,,	529·1
03·75	2		,,	,,	532·7
02·94	2		,,	,,	539·3
02·13	1		,,	,,	545·9
01·61	2		,,	,,	550·2
01·03	1		,,	,,	554·9
00·70	1		,,	,,	557·6
00·45	1		,,	,,	559·7
00·15	2		,,	,,	562·1
3499·15	2		,,	,,	570·3
98·77	1		,,	,,	573·4
98·15	2		,,	,,	579·4
97·85	1		,,	,,	580·9
97·41	1		,,	,,	584·5
97·19	1		,,	,,	586·3
96·94	1		,,	,,	588·3
95·90	1		,,	,,	596·8
93·69	2		,,	,,	614·9
93·47	1		,,	,,	616·7
92·85	1		,,	,,	621·8
91·75	1		,,	,,	630·8
90·62	2		,,	,,	639·3
90·42	1		,,	,,	641·7
89·99	1		,,	,,	645·3
88·00	2		,,	,,	661·6
87·15	2n		,,	,,	668·6
86·67	3		,,	,,	672·6
85·63	1n		,,	,,	681·1
85·35	2		,,	,,	683·4
84·25	1		,,	,,	692·4
83·56	1n		,,	,,	698·2
83·36	2		,,	,,	699·8
82·96	2*		,,	,,	703·9
82·70	2		,,	,,	705·3
81·20	1		,,	,,	717·6
79·33	2		,,	,,	733·0

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
3479·25	1		1·27	8·1	28733·7
78·60	2		,,	,,	739·1
78·28	2		,,	,,	741·7
77·84	2		,,	,,	745·4
77·06	1		,,	,,	751·8
76·70	2		,,	,,	754·8
76·13	1		,,	,,	759 5
75·71	1		,,	,,	763·0
74·46	1		,,	,,	773·3
73·97	1		,,	,,	777·4
73·59	2		,,	,,	780·5
73·21	2		,,	,,	783·7
70·08	5r		,,	,,	809·6
69·50	1		,,	,,	814·4
68·83	1		,,	,,	820·0
68·36	3		,,	,,	823·8
68 07	1		,,	,,	826·3
67·05	1		,,	,,	834·8
65·88	4r		,,	,,	844·5
65·17	1		,,	,,	850·4
64 58	1 Sr ?		,,	,,	855·3
63·86	3		,,	,,	861·3
63·00	4r		,,	,,	868·5
61·37	1		,,	,,	882·1
61·20	1		,,	,,	883·5
59·75	1		,,	,,	895·6
59·69	1		,,	,,	896·1
58·06	1		,,	,,	909·8
57·80	1		,,	,,	911·9
57·08	1		,,	,,	917·9
56·57	1		,,	,,	920·5
56·10	1		,,	8·2	926·2
55·40	1		,,	,,	932·0
55·1	1n		,,	,,	934·5
54·83	1		,,	,,	936·8
54·35	2		,,	,,	942·8
54·05	1		,,	,,	949·3
53·68	1		,,	,,	946 4
52 81	2		,,	,,	953·7
51·85	1		,,	,,	961·8
51·13	2		,,	,,	967·8
50·9	1n		,,	,,	970
50·0	1n		,,	,,	977
49·77	2		,,	,,	979·2
49·42	2		,,	,,	982·2
48·9	1n		,,	,,	986·5
47·75	1		,,	,,	996·2
46·68	1		,,	,,	29005·2
45·87	2		,,	,,	012·0
45·50	1		,,	,,	015·2
45·34	2		,,	,,	016·5
44·15	1		,,	,,	026·5
43·25	1		,,	,,	029·9
41·49	2		,,	,,	049·0
41·16	2		,,	,,	051·8

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
3439·83	4		1·27	8·2	29063·0
39·07	3		,,	,,	069·5
37·13	1		,,	,,	085·9
36·80	2		,,	,,	088·6
36·05	3r		,,	,,	095·0
34·86	2		,,	,,	105·1
34·09	4		,,	8·3	111·6
31·95	2		,,	,,	129·7
31·16	1		,,	,,	136·4
30·70	1		,,	,,	140·3
30·50	1		,,	,,	142·0
29·99	2		,,	,,	146·4
29·47	2		,,	,,	150·7
29·10	1		,,	,,	153·8
28·09	1		,,	,,	162·4
27·58	1		,,	,,	165·8
27·1	1n		,,	,,	171
26·20	1n		,,	,,	178·5
26·04	1		,,	,,	179·9
25·28	2		,,	,,	186·4
24·09	1		,,	,,	196·6
23·24	2		,,	,,	203·8
22·70	1		,,	,,	208·4
21·31	2		,,	,,	220·3
19·29	3		,,	,,	237·5
18·99	2		,,	,,	240·1
18·89	2		,,	,,	241·0
17·83	1		,,	,,	250·0
17·22	1		,,	,,	255·4
16·54	1		,,	,,	261·2
16·03	1		,,	,,	265·5
15·2	1b		,,	,,	273
14·59	2		,,	,,	277·8
13·52	1		,,	,,	287·0
13·15	1		,,	,,	290·2
12·53	1n		,,	,,	295·5
11·92	2		,,	,,	300·7
11·50	1		,,	,,	304·3
09·37	2		,,	,,	322·6
08·76	2		,,	,,	327·9
07·76	1		,,	,,	336·5
06·84	1		,,	,,	344·4
05·70	1		,,	,,	354·2
04 75	2		,,	,,	362·4
03·42	2		,,	,,	373·9
02·81	4		,,	,,	379·2
02·16	2		,,	,,	384·8
01·78	2		,,	,,	388·1
01·17	1n		,,	,,	393·4
3398·70	1		,,	,,	414·7
98·02	1		,,	,,	421·6
97·65	1		,,	8·4	423·7
97·23	1		,,	,,	427·4
96·7	1n		,,	,,	432
96·53	1		,,	,,	433·4

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
3395·77	1		1·27	8·4	29440·0
95·50	1		,,	,,	442·3
95·26	1		,,	,,	444·4
94·96	1		,,	,,	447·0
94·64	1		,,	,,	449·8
94·27	1		,,	,,	452·9
93·35	1		,,	,,	461·0
93·05	1		,,	,,	463·6
92·20	5		,,	,,	471·0
91·85	1		,,	,,	474·0
90·93	1		,,	,,	482·0
90·48	1		,,	,,	485·9
89·77	3		,,	,,	492·1
88·70	2		,,	,,	501·4
86·64	3		,,	,,	519·4
85·66	3		,,	,,	527·9
85·16	1		,,	,,	532·3
83·27	3		,,	,,	548·8
83·02	1 Ag		,,	,,	551·0
81·51	2		,,	,,	564·2
79·9	2b		,,	,,	578
79·28	1		,,	,,	583·7
78·70	3		,,	,,	588·8
77·57	8		,,	,,	598·7
76·98	1		,,	,,	603·9
75·15	1		,,	,,	619·9
74·73	3		,,	,,	623·6
72·85	1		,,	,,	640·2
71·96	3		,,	,,	647·9
71·65	1		,,	,,	650·7
70·95	1		,,	,,	656·8
70·53	1		,,	,,	660·5
69·23	1n		,,	,,	671·1
67·93	3		,,	,,	683·4
66·8	1n		,,	,,	693
66·64	2		,,	,,	694·8
65·75	1n		,,	,,	702·7
65·43	1 Cu ?		,,	,,	705·5
64·79	2		,,	,,	711·1
63·84	2		,,	,,	719·5
63·20	1		,,	,,	725·1
62·80	1		,,	,,	728·7
62·68	1		,,	,,	729·7
62·35	1		,,	,,	732·7
61·82	3		,,	,,	737·4
60·51	2		,,	8·5	748·1
60·30	1		,,	,,	750·7
59·87	1		,,	,,	754·7
59·20	1		,,	,,	760·4
58·74	3		,,	,,	764·6
57·48	1		,,	,,	775·7
57·38	1		,,	,,	776·6
57·21	1		,,	,,	778·1
56·96	1		,,	,,	780·4
55·96	2		,,	,,	789·2

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
3355·38	2		1·27	8 5	29794·4
54·74	2		,,	,,	800·0
54·35	3		,,	,,	803·5
54·10	1		,,	,,	805·8
53·31	1		,,	,,	812·8
51·75	1		,,	,,	826·7
51·38	4		,,	,,	830·0
50·43	1		,,	,,	838·4
49·99	1		,,	,,	842·3
49·48	1		,,	,,	846·9
49·10	2		,,	,,	850·3
47·72	1		,,	,,	862 6
46·68	2		,,	,,	871·9
45·01	2r		,,	,,	886·8
44·46	1		,,	,,	891·7
43·77	2r		,,	,,	898·4
43·41	1		,,	,,	901·1
42·37	1n		,,	,,	910·4
39·70	6		,,	,,	934·3
38·50	1		,,	,,	945·1
38·00	3		,,	,,	949·6
37·65	1		,,	,,	952·7
37·26	1		,,	,,	956·2
36·9	1n Mg?		,,	,,	959
36·26	1n		,,	,,	965·2
35·17	1		,,	,,	974·9
34·72	4		,,	,,	979·0
34·18	1n		,,	,,	983·9
33·50	1n		,,	,,	990·0
32·56	1		,,	,,	998·4
32·22	1		,,	,,	30001·5
31·30	1		,,	,,	009·8
30·62	1		,,	,,	015·9
28·40	1n		,,	,,	036·0
27·86	1n		,,	,,	040·8
27·32	1		,,	,,	045·7
26·58	1		,,	,,	052·4
25·27	4r		,,	,,	064·2
24·88	2		,,	8·6	067·7
22·60	1		,,	,,	088·3
21·57	3		,,	,,	097·6
20·97	3n		,,	,,	103·1
20·42	2		,,	,,	108·1
19·76	1		,,	,,	114·1
19·09	1		,,	,,	120·1
18·35	1n		,,	,,	126·9
17·90	1		,,	,,	131·0
17·7	1n		,,	,,	133
16·37	1		,,	,,	144·8
14·99	2		,,	,,	157·4
13·87	10		,,	,,	167·6
12·23	1		,,	,,	182·5
10·65	1n		,,	,,	196·8
10·35	2		,,	,,	199·7
09·25	1		,,	,,	209·7

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
3308·20	1		1·27	8·6	30219·3
04·33	1		,,	,,	254·7
03·59	1		,,	,,	261·5
01·81	1*		,,	,,	277·8
01·44	2		,,	,,	281·2
00·63	12		,,	,,	288·6
3299·80	1		,,	,,	296·3
97·95	2		,,	,,	314·2
97·47	1		,,	,,	317·7
96·72	2		,,	,,	324·6
95·65	1		,,	,,	334·4
95·44	1		,,	,,	336·4
95·12	1		,,	,,	339·3
94·76	1		,,	,,	342·8
94·67	1		,,	,,	343·4
94·37	1		,,	,,	346·2
94·06	2		,,	,,	349·1
93·79	1		,,	,,	351·6
93·71	1		,,	,,	352·3
92·62	3		0·92	,,	361·9
91·88	3		,,	,,	369·2
91·50	1		,,	,,	372·7
90·73	10		,,	,,	379·8
90·25	1		,,	8·7	384·2
88·27	1		,,	,,	402·4
87·90	2		,,	,,	406·8
86·71	2		,,	,,	416·9
84·23	2n		,,	,,	439·8
83·11	2		,,	,,	450·2
82·75	2		,,	,,	453·6
82·2	1b		,,	,,	459
81·56	1		,,	,,	464·6
81·42	1		,,	,,	465·9
80·84	1		,,	,,	471·3
80·52	2		,,	,,	474·3
78·90	1		,,	,,	489·3
76·30	1		,,	,,	513·5
75·20	2r		,,	,,	523·8
74·55	1		,,	,,	529·8
72·5	16		,,	,,	549
71·3	1n		,,	,,	560
70·97	1		,,	,,	563·3
70·37	1		,,	,,	568·8
69·57	1		,,	,,	576·3
67·65	2		,,	,,	594·3
66·45	1		,,	,,	605·6
65·67	1		,,	,,	612·9
64·56	1		,,	,,	623·3
64·26	1		,,	,,	626·1
63·8	1n		,,	,,	630
63·16	1		,,	,,	636·4
62·79	3		,,	,,	639·9
61·66	1		,,	,,	650·5
61·2	1n		,,	,,	655
61·04	1		,,	,,	656·4

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
3259·82	1		0·92	8·7	30667·8
59·35	1		,,	,,	672·3
58·2	1n		0·91	,,	683
58·05	1		,,	,,	684·7
57·27	2		,,	,,	691·9
56·38	3		,,	,,	700·2
55·62	2		,,	,,	707·4
54·96	1		,,	,,	713·7
53·12	1		,,	,,	731·0
52·85	1		,,	8·8	733·5
52·02	1		,,	,,	741·3
50·3	1n		,,	,,	757·5
50·06	1		,,	,,	759·9
49·02	1		,,	,,	769·7
48·62	2n		,,	,,	773·5
46·73	1		,,	,,	791·4
45·91	3		,,	,,	799·2
44·64	1		,,	,,	811·1
43·96	1		,,	,,	817·8
43·18	1		,,	,,	825·2
42·42	2n		,,	,,	832·4
41·70	1		,,	,,	839·2
41·25	3		,,	,,	843·5
40·62	2n		,,	,,	849·5
39·38	1		,,	,,	861·3
38·91	1		,,	,,	865·8
38·23	3		,,	,,	872·3
37·36	1n		,,	,,	890·1
35·95	2		,,	,,	894·0
35·00	1		,,	,,	903·1
33·70	1		,,	,,	915·5
33·48	1		,,	,,	917·6
32·87	1		,,	,,	923·5
32·21	7		,,	,,	928·8
30·98	2		,,	,,	951·6
29·10	3		,,	,,	959·6
27·90	2		,,	,,	971·1
27·10	1		,,	,,	978·9
26·52	1		,,	,,	984·3
26·23	1		,,	,,	986·2
25·80	1		,,	,,	991·3
25·51	2		,,	,,	994·0
24·55	1		,,	,,	31003·3
23·93	1		,,	,,	009·2
23·40	1		,,	,,	014·3
22·00	1		,,	,,	027·8
21·40	12		,,	,,	033·6
20·46	1		,,	,,	038·1
18·94	1		,,	,,	057·3
18·45	1		,,	,,	062·0
17·94	1		,,	,,	067·0
17·56	1		,,	,,	070·6
16·71	8		,,	,,	078·8
15·92	1		,,	8·9	086·4
13·71	2		,,	,,	107 8

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
3212·96	1n		0·91	8·9	31115·0
12·17	1n		,,	,,	122·6
10·43	2		,,	,,	139·5
09·47	1n		,,	,,	148·9
08·15	1		,,	,,	161·7
07·88	1		,,	,,	164·3
07·03	1		,,	,,	172·6
06·30	1		,,	,,	179·7
05·45	1n		,,	,,	188·0
04·02	1		,,	,,	201·9
03·75	1		,,	,,	204·5
03·36	1		,,	,,	208·3
02·25	1		,,	,,	219·1
3199·09	1		,,	,,	250·0
98·83	1		,,	,,	252·5
98·60	1		,,	,,	254·8
98·34	1		,,	,,	267·3
97·73	1n		,,	,,	273·3
95·90	1		,,	,,	279·2
95·45	1		,,	,,	285·6
93·50	1		,,	,,	304·7
93·29	1		,,	,,	306·7
92·25	1		,,	,,	316·9
91·98	1		,,	,,	319·6
91·33	1*		,,	,,	326·0
90·86	1		,,	,,	330·6
90·25	2*		,,	,,	336·6
88·38	5		,,	,,	355·0
87·56	1		,,	,,	364·0
87·14	1		,,	,,	367·1
85·05	2		,,	,,	387·7
84·06	1n		,,	,,	397·5
83·94	1		,,	,,	398·7
83·70	1		,,	,,	401·1
82·80	1		,,	,,	409·9
82·52	1		,,	,,	412·7
81·9	1n		,,	,,	419
81·33	1		,,	,,	424·5
80·35	4		,,	9·0	434·0
79·18	2		,,	,,	445·6
78·91	1		,,	,,	448·3
78·00	1		,,	,,	457·3
77·65	1		,,	,,	460·8
77·33	1		,,	,,	463·9
76·65	1		,,	,,	470·7
75·84	3		,,	,,	478·7
74·62	1		,,	,,	490·8
74·34	1		,,	,,	493·6
73·3	1b		,,	,,	504
72·65	1		,,	,,	510·4
72·24	1		,,	,,	514·5
71·84	1		,,	,,	518·4
70·53	1		,,	,,	531·5
69·98	1n		,,	,,	538·9
69·43	1		,,	,,	542·4

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
3167·66	1		0·91	9·0	31560·0
66·63	1n		,,	,,	570·0
66·25	1		,,	,,	574·1
65·94	1		,,	,,	577·2
65·8	1n		,,	,,	579
64·60	1		,,	,,	590·6
62·95	1		,,	,,	607·0
62·9	1b		,,	,,	611·5
61·81	1		,,	,,	618·4
60·95	1n		,,	,,	627·1
60·3	1n		,,	,,	634
59·20	1		,,	,,	644·6
58·72	1		,,	,,	649·4
58·02	1		,,	,,	656·4
56·49	1		,,	,,	671·7
55·93	1		,,	,,	677·4
54·89	3		,,	,,	687·8
54·40	2		,,	,,	692·7
51·9	1n		,,	,,	718
51·75	1		,,	,,	719·4
50·56	2		,,	,,	731·4
50·08	1		,,	,,	736·1
48·11	5		,,	,,	756·1
46·15	2		,,	9·1	765·7
42·95	2r		,,	,,	808·2
42·41	3n		,,	,,	813·6
41·95	2		,,	,,	818·3
41·03	1		,,	,,	827·6
39·38	3		,,	,,	844·3
37·25	1n		,,	,,	864·9
36·83	1		,,	,,	870·2
34·50	2		,,	,,	893·9
33·70	1		,,	,,	902·1
31·17	1 Be ?		,,	,,	927·8
30·08	1		,,	,,	939·0
27·26	1		,,	,,	967·9
25·60	3		,,	,,	984·7
25·27	2		,,	,,	988·2
24·47	3		,,	,,	996·4
23·05	3		,,	,,	32011·1
22·5	1b		,,	,,	016·5
21·1	1n		,,	,,	031
19·60	3		,,	,,	046·3
17·75	2		,,	,,	065·3
16·56	1		,,	,,	074·2
16·4	1n		,,	,,	078
16·9	1n		,,	,,	079
14·1	1b		,,	,,	103
12·46	4		,,	,,	119·7
11·9	1n		,,	,,	125·5
10·92	2		,,	,,	135·6
08·37	3		,,	,,	162·0
07·11	2		,,	,,	175·0
06·76	1		,,	,,	168·7
05·83			,,	,,	188·3

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
3105·12	1		0·91	9·1	32195·7
04·50	1		,,	,,	202·1
02·76	1		,,	,,	220·2
01·80	1		,,	,,	230·1
01·02	2		,,	,,	238·2
3099·90	1		,,	9·2	249·9
98·04	6		,,	,,	269·3
97·35	1		,,	,,	276·5
96·50	1n		,,	,,	285·3
94·8	1n		,,	,,	303·1
93·11	1		,,	,,	320·7
92·46	1		,,	,,	327·5
90·20	1		,,	,,	351·1
89·72	1		,,	,,	356·2
88·54	2		,,	,,	368·5
84·40	2n		,,	,,	412·0
84·10	1n		,,	,,	415·2
82·30	1		,,	9·3	434·0
82·06	1		,,	,,	436·7
81·80	1		,,	,,	440·3
80·31	3		,,	,,	454·9
80·00	1		,,	,,	458·2
78·99	4		,,	,,	468·9
78·02	1		,,	,,	479·1
77·44	1		,,	,,	485·2
76·05	1n		,,	,,	499·9
75·18	1		,,	,,	508·1
72·92	1		,,	,,	533·0
72·22	2		,,	,,	540·4
70·95	3		,,	,,	554·1
69·35	1n		,,	,,	570·8
69·06	1		,,	,,	573·1
67·81	3		,,	,,	587·2
66·33	2n r		,,	,,	602·9
66·03	1		,,	,,	606·2
63·15	3r		,,	,,	636·6
61·79	2		,,	,,	652·0
61·4	1n		,,	,,	655·5
60·27	2		,,	,,	667·4
58·51	1		,,	,,	686·2
58·00	1n		,,	,,	691·8
51·90	1n		,,	9·4	757·1
51·03	1n		,,	,,	766·4
49·9	1n		,,	,,	779
49·7	1n		,,	,,	781
49·16	2		,,	,,	786·5
47·06	2		,,	,,	809·1
45·67	1		,,	,,	824·0
43·20	1n		,,	,,	850·7
40·2	1n		,,	,,	883
38·7	1n		,,	,,	899
35·21	2		,,	,,	936·9
34·17	3		,,	,,	948·2
33·25	1n		,,	,,	958·5
32·08	1		,,	,,	971·3

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
3031·40	1		0·91	9·4	32978·7
28·69	1		,,	,,	33008·1
27·9	1b		,,	,,	017
26·68	2		,,	,,	030·1
22·22	1		,,	9·5	078·7
21·61	1		,,	,,	085·4
19·52	1		,,	,,	108·3
18·62	1		,,	,,	118·1
17·26	1		,,	,,	133·1
15·87	1		,,	,,	148·4
15·08	1n		,,	,,	157·1
13·80	1n		,,	,,	171·2
12·85	1n		,,	,,	181·8
11·75	1n		,,	,,	193·8
09·90	1		,,	,,	214·2
08·61	2		,,	,,	228·4
08·0	1n		,,	,,	235
07·75	1		,,	,,	237·9
07·03	2		,,	,,	245·9
06·10	1		,,	,,	256·2
02·51	2		,,	,,	295·9
01·37	2		,,	,,	308·6
2999·93	1		,,	,,	324·6
99·23	2r		,,	,,	332·3
97·11	1		,,	9·6	355·9
95·90	2		,,	,,	369·4
93·91	3		,,	,,	391·5
91·82	1		,,	,,	414·9
91·20	1		,,	,,	421·8
88·33	3		,,	,,	455·8
86·92	1		,,	,,	469·7
86·20	1n		,,	,,	477·7
85·38	1		,,	,,	486·9
83·97	2		,,	,,	502·8
91·59	2		,,	,,	529·5
80·5	1n		,,	,,	542
78·80	8		,,	9·7	560·9
77·4	1n		,,	,,	577
76·85	1n		,,	,,	582·8
76·18	1		,,	,,	590·3
75·06	2		,,	,,	603·1
74·15	2		,,	,,	613·3
73·67	2		,,	,,	618·4
72·36	1		,,	,,	623·4
71·63	1		,,	,,	641·8
68·81	2		,,	,,	673·8
65·64	1		,,	,,	709·8
65·05	1		,,	,,	716·5
64·17	1n		,,	,,	726·5
61·9	1n		,,	,,	751
61·62	2		,,	,,	755·6
58·20	1n		,,	,,	794·6
58·04	2		,,	,,	796·5
57·70	2		,,	,,	800·4
55·1	1n		,,	,,	830

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda+$	$\frac{1}{\lambda}-$	
2951·37	1		0·91	9·7	33872·8
50·60	1		,,	,,	881·7
50·02	1		,,	,,	888·4
49·15	1		,,	,,	898·3
46·75	1n		,,	,,	926·0
42·97	3		,,	,,	969·6
40·73	1		,,	,,	995·4
39·65	1		,,	,,	34008·9
38·27	2n		,,	,,	023·8
37·51	1		,,	,,	032·6
36·54	2		,,	9·8	043·9
36·25	1		,,	,,	047·2
35·8	1n		,,	,,	052·5
33·19	1		,,	,,	082·9
32·59	5		,,	,,	089·2
31·00	1		,,	,,	108·2
29·33	1		,,	,,	127·1
28·77	2		,,	,,	134·2
28·30	2		,,	,,	139·7
25·70	2n		,,	,,	170·1
25·14	3		,,	,,	176·6
24·05	2n		,,	,,	189·3
22·68	2r		,,	,,	205·4
21·70	2		,,	,,	216·8
21·05	1n		,,	,,	224·4
20·44	1		,,	,,	231·6
19·91	1		,,	,,	237·8
17·90	2		,,	,,	261·4
17·50	1		,,	,,	266·1
17·13	1		,,	,,	270·5
16·55	1n		,,	9·9	277·2
14·5	1b		,,	,,	301
12·82	1		,,	,,	321·2
12·10	1		,,	,,	329·6
11·42	1		,,		337·6
10·71	2		,,	,,	346·0
10·31	2		,,	,,	350·7
08·41	1		,,	,,	373·1
06·05	1n		,,	,,	401·0
04·36	1		,,	,,	421·1
03·24	1		,,	,,	434·2
2899·81	2		,,	,,	475·1
99·52	1		,,	,,	478·5
99·03	6		,,	,,	484·4
98·40	1		,,	,,	491·8
97·19	1		,,	,,	506·3
96·81	4		,,	10·0	510·8
95·24	1		,,	,,	529·5
95·25	1		,,	,,	565·2
91·87	2		,,	,,	569·7
91·35	2		,,	,,	575·9
89·1	1b		,,	,,	603
87·40	3		,,	,,	623·2
86·62	1		,,	,,	632·6
86·3	1n		,,	,,	636

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
2885·15	3		0·91	10·0	34650·1
84·38	3		,,	,,	659·4
82·61	1		,,	,,	680·7
82·13	1		,,	,,	686·6
81·24	1		,,	,,	697·3
79·65	1		,,	,,	716·4
79·30	1		,,	,,	720·7
76·51	1		,,	,,	754·3
75·73	1		,,	,,	763·8
71·83	1		,,	10·1	810·9
70·95	1		,,	,,	821·6
70·51	3		,,	,,	826·9
70·04	1		,,	,,	832·6
68·73	1		,,	,,	848·5
64·74	1		,,	,,	897·1
62·66	1n		,,	,,	922·4
61·48	3		,,	,,	936·8
57·57	1		,,	,,	984·6
55·97	1		,,	,,	35004·3
55·00	1		,,	,,	016·2
54·22	1		,,	,,	025·6
52·60	1		,,	,,	045·6
51·4	1n		,,	,,	060
61·35	2		,,	,,	061·0
48·1	1n		,,	10·2	101
47·45	1		,,	,,	108·9
45·98	1		,,	,,	127·1
42·90	2		,,	,,	165·1
41·25	1		,,	,,	185·6
40·25	1		,,	,,	197·9
39·33	1		,,	,,	209·3
37·40	5		,,	,,	233·3
36·14	1		,,	,,	249·0
34·57	2		,,	,,	268·5
33·46	1		,,	,,	282·3
32·48	4		,,	,,	294·5
30·54	1		,,	,,	318·5
30·02	1		,,	,,	325·2
28·10	1		,,	,,	349·2
27·90	1		,,	,,	351·7
26·95	2		,,	,,	363·9
24·78	3		,,	,,	390·8
23·70	1n		,,	10·3	404·2
23·50	1 M ?		,,	,,	409·2
22·6	1b		,,	,,	418
22·14	1		,,	,,	425·8
21·75	1		,,	,,	428·7
20·46	1		,,	,,	444·9
19·41	2		,,	,,	458·1
16·18	1		,,	,,	498·8
14·71	1		,,	,,	519·3
14·44	1		,,	,,	520·7
11·49	1		,,	,,	558·0
09·08	2		,,	,,	588·5
07·40	2		,,	,,	609·8

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
2803·52	1		0·91	10·3	35659·1
00·69	1		,,	,,	695·1
2799·22	1		,,	10·4	713·8
98·80	1		,,	,,	719·2
97·17	1		,,	,,	740·2
94·39	2		,,	,,	775·6
91·55	1n		,,	,,	812·0
91·15	1		,,	,,	817·1
90·53	1		,,	,,	823·8
88·80	1		,,	,,	847·3
87·79	1		,,	,,	860·3
87·25	2		,,	,,	867·2
87·02	2		,,	,,	870·2
86·40	1		,,	,,	878·1
85·71	1n		,,	,,	887·1
85·09	1		,,	,,	895·1
84·48	2		,,	,,	902·9
84·20	1n		,,	,,	906·4
83·64	1n		,,	,,	913·7
83·18	2		,,	,,	919·6
80·85	1		,,	,,	949·8
80·58	1		,,	,,	953·3
78·85	1		,,	,,	975·7
77·94	1		,,	,,	988·5
76·98	1		,,	10·5	999·8
75·22	2		,,	,,	36022·5
75·00	1		,,	,,	025·5
74·61	2*		,,	,,	030·6
71·63	3		,,	,,	069·4
70·95	2		,,	,,	078·2
68·97	4		,,	,,	104·0
65·97	3		,,	,,	143·2
65·24	2		,,	,,	152·7
64·76	2		,,	,,	159·0
63·73	2		,,	,,	171·5
61·7	1n		,,	,,	199
60·83	2n		,,	,,	210·5
60·52	2		,,	,,	214·5
59·93	1		,,	,,	222·3
57·30	1n		,,	,,	256·9
52·30	3		,,	,,	320·8
49·8	1n		,,	10·6	356
49·67	1		,,	,,	357·4
48·93	1		,,	,,	367·2
47·98	1		,,	,,	380·0
47·77	1		,,	,,	382·5
47·29	2		,,	,,	388·9
44·1	1b		,,	,,	431
43·20	1		,,	,,	443·2
38·43	1		,,	,,	506·6
37·52	2		,,	,,	518·8
36·53	1		,,	,,	532·0
35·5	1b		,,	,,	546

* Double.

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
2734·48	2		0·91	10·6	36559·4
32·88	3		,,	,,	580·8
31·62	2		,,	,,	597·7
30·36	2		,,	,,	614·6
29·40	3		,,	,,	627·5
27·6	1n		,,	,,	652
27·4	1n		,,	,,	654
26·53	1		,,	10·7	665·9
25·5	1n		,,	,,	688·5
23·43	1		,,	,,	707·7
22·46	2		,,	,,	720·7
21·81	3		,,	,,	729·6
21·46	1		,,	,,	734·3
20·02	1		,,	,,	753·7
19·57	1		,,	,,	762·5
16·36	2		,,	,,	803·2
15·20	1		,,	,,	819·0
14·75	1		,,	,,	825·1
11·59	1		,,	,,	868·0
10·1	1n		,,	,,	888
08·36	4		,,	,,	912·0
04·05	3		,,	,,	970·8
01·95	1		,,	10·8	37009·5
00·9	1b		,,	,,	014
2698·84	1		,,	,,	042·1
97·67	1		,,	,,	058·2
96·94	1		,,	,,	068·3
95·93	1		,,	,,	082·1
95·65	3		,,	,,	086·0
95·31	2		,,	,,	090·6
94·10	3		,,	,,	107·4
92·50	3		,,	,,	129·4
91·29	1		,,	,,	146·0
88·42	1		,,	,,	185·8
87·22	3		,,	,,	202·2
86·77	6		,,	,,	209·1
84·43	3		,,	,,	240·9
81·09	3		,,	,,	287·5
79·07	1		,,	10·9	315·5
78·2	1b		,,	,,	328
76·7	1b		,,	,,	348·5
75·80	1		,,	,,	361·1
73·77	2		,,	,,	389·5
71·7	1b		,,	,,	418
68·05	1		,,	,,	469·6
67·00	2		,,	,,	484·4
62·95	1		,,	,,	541·4
62·46	1		,,	,,	548·3
61·50	1		,,	,,	561·9
60·0	1n		,,	,,	583
58·77	1		,,	,,	600·4
52·22	1		,,	11·0	693·3
50·71	2 Be ?		,,	,,	714·7
50·00	1		,,	,,	724·8
49·62	1		,,	,,	725·4

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$	
2644·9	1n		0·91	11·0	37798
43·4	1n		,,	,,	820
42·75	1n		,,	,,	828·4
41·62	2		,,	,,	846·0
40·43	1		,,	,,	861·6
40·00	1		,,	,,	868·8
39·61	1		,,	,,	873·4
38·71	2		,,	,,	886·0
37·76	1		,,	,,	899·9
35·96	2		,,	,,	925·8
35·5	1n		,,	,,	932·5
33·45	1		,,	,,	962·0
30·13	1		,,	11·1	38009·8
28·92	1		,,	,,	027·3
26·50	1		,,	,,	062·4
25·86	2		,,	,,	071·8
23·57	2		,,	,,	104·9
19·02	2		,,	,,	180·2
15·49	1		,,	,,	222·6
09·97	2		,,	,,	303·5
09·31	3		,,	11·2	313·0
08·46	1		,,	,,	325·5
04·03	1		,,	,,	389·9
01·03	1n		,,	,,	434·1
00·72	3		,,	,,	439·7
2597·41	3		,,	,,	488·7
97·16	2		,,	,,	492·4
95·16	1		,,	,,	522·0
92·92	1		,,	,,	555·4
89·17	2		,,	,,	611·1
86·24	1		,,	,,	654·8
83·48	4		,,	,,	696·2
80·85	1 Ag ?		,,	11·3	735·6
80·48	1		,,	,,	741·1
79·56	2		,,	,,	743·9
76·44	1		,,	,,	801·8
74·60	1		,,	,,	829·7
71·72	5		,,	,,	873·2
67·92	3		,,	11·4	930·6
66·70	3		,,	,,	949·1
65·70	3		,,	,,	964·3
64·50	6		,,	,,	982·5
62·04	1		,,	,,	39020·0
61·13	1		,,	,,	033·9
59·26	1		,,	,,	062·3
55·31	4		,,	,,	122·6
54·80	4		,,	,,	182·6
51·41	1		,,	,,	192·0
50·8	1n		,,	,,	202
50·12	1		,,	,,	207·9
49·66	4		,,	11·5	216·1
49·21	3		,,	,,	227·0
48·24	1		,,	,,	234·8
48·01	2		,,	,,	268·9
45·80	1		,,	,,	278·1

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
2545·20	4		0·91	11·5	39316·8
42·70	1n		,,	,,	327·6
42·00	2		,,	,,	407·7
36·83	1n		,,	,,	410·5
36·65	3		,,	,,	436·8
35·96	1		,,	,,	444·8
34·45	1		,,	,,	456·0
33·73	1		,,	,,	474·2
32·56	1		,,	11·6	513·1
30·06	3		,,	,,	519·9
29·63	1		,,	,,	538·3
28·45	2		,,	,,	575·0
26·02	1n		,,	,,	641·0
21·9	1b		,,	,,	659
20·77	1		,,	,,	666·8
20·26	1		,,	,,	725·1
16·56	1		,,	,,	759·3
14·40	4		,,	,,	784·5
12·81	8		,,	11·7	807·3
11·35	1		,,	,,	827·5
10·09	1		,,	,,	860·4
08·02	1		,,	,,	897·1
05·71	1		,,	,,	918·2
04·39	2		,,	,,	940·4
03·00	1		,,	,,	968·9
01·21	5		,,	,,	40012·3
2498·49	1		,,	,,	024·8
97·69	3		,,	,,	030·8
97·35	3		,,	,,	060·9
95·47	1		,,	,,	072·6
94·74	1 Be ?		,,	11·8	153·5
89·72	2		,,	,,	359·1
77·07	1		,,	11·9	385·3
75·41	4		,,	,,	407·0
74·09	5		,,	,,	461·8
70·74	2		,,	,,	502·3
68·27	1		,,	,,	510·8
67·75	2		,,	,,	535·1
66·27	1		,,	,,	584·1
63·30	7		,,	,,	605·6
61·99	1		,,	,,	615·7
61·38	1		,,	12·0	653·6
59·08	1		,,	,,	657·1
58·87	1		,,	,,	789·0
56·94	1		,,	,,	797·8
56·41	1		,,	,,	802·4
50·91	1		,,	,,	803·7
45·64	1		,,	12·1	948·3
41·38	9		,,	,,	981·7
39·39	1		,,	,,	41009·0
37·65	1		,,	,,	089·9
32·97	1		,,	,,	109·4
31·82	7		,,	,,	119·3
31·23	1		,,	,,	159·0
28·89	1		,,	12·2	172·9
28·06	8		,,	,,	216·5

THORIUM (ULTRA-VIOLET SPARK SPECTRUM)—*continued.*

Wave-length (Exner and Haschek)	Intensity and Character	Wave-length (Lohse)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
2425·5	1b		0·91	12·2	41230·2
24·69	3		"	"	245·5
23·79	2		"	"	430·0
13·58	6		"	12·3	457·0
11·42	1		"	"	499
03·2	1n		"	12·4	528·6
2395·72	2		"	"	572·3
93·21	1		"	"	800·3
91·62	3		"	"	859·8
88·23	1		"	"	872·2
86·94	1		"	12·5	966·4
82·15	2		"	"	976·1
81·60	2		"	"	42041·0
77·92	2		"	"	076·4
75·92	1		"	"	089·4
75·19	1		"	"	112·3
73·90	1		"	"	152·9
71·50	4		"	"	163·1
69·04	2		"	"	214·0
68·18	1		"	"	232·9
67·12	1		"	12·6	313·0
63·19	4		"	"	318·7
62·32	1		"	"	408·8
57·30	1		"	"	432·4
55·99	2		"	"	443·9
55·35	1		"	12·7	465·3
54·16	1		"	"	507·8
51·81	1		"	12·8	709·0
40·72	3		"	"	803·8
35·59	3		"	"	930·2
28·67	1		"	12·9	960·7
27·01	1		"	"	43001·5
24·80	3		"	"	098·3
19·58	4		"	13·0	246·7
11·62	1		"	"	334
07·2			"	"	440·3
01·32			"	13·1	515·3
2297·35			"	"	621·6
91·76			"	13·2	798·5
87·71			"	"	763·3
84·33			"	"	814·0
81·69			"	"	836·1
80·54			"	"	867·0
78·93			"	13·4	44280
57·7			"	13·5	439
49·6			"	13·6	821
30·4			"	"	852
28·9			"	13·7	957·4
23·65			"	"	45098·6
21·61			"	"	008·0
21·15			"	13·8	301·7
06·75			"	13·9	442·8
2199·90			"	"	466·1
98·78			"	"	501·0
92·48					

The Nature of Alloys.—Report of the Committee consisting of Mr. F. H. NEVILLE (*Chairman and Secretary*), Mr. C. T. HEYCOCK, *and* Mr. E. H. GRIFFITHS.

THE research for which this Committee was formed is completed, and a summary of the results has been published in the 'Proceedings of the Royal Society,' vol. lxix., p. 320. A copy of this paper has been sent to the Secretary of the British Association.

The work consists in a study of the chemical compounds and solid solutions to be found in alloys composed of copper and tin.

At least three series of solid solutions are formed during the solidification of these alloys.

The first series, which may be called Alpha, consists of crystals, isomorphous with pure copper, and varying in composition from pure copper to an alloy containing about 9 per cent. by weight of tin. These alloys solidify to a uniform mass, and apparently remain unchanged at all lower temperatures.

The second series, which may be called Beta, contains percentages of tin varying from 22·5 per cent. to 32 per cent. Alloys between 9 per cent. and 22·5 per cent. of tin solidify as a complex of crystals of Alpha and of Beta. But all the alloys from 9 per cent. to 32 per cent. of tin undergo important re-crystallisations after they have wholly solidified, and their final condition below 500° C. is that of a complex of Alpha and a crystalline body which is probably Cu_4Sn.

Alloys from 32 per cent. of tin to 57 per cent. begin to solidify by the formation of a third type of crystalline solid solutions, which may be called Gamma. But the Gamma crystals break up at lower temperatures into a complex of crystals of the body Cu_3Sn and another substance. The alloy of the formula Cu_3Sn is apparently a solid solution when first solidified, and is not converted into the compound until a lower temperature is reached.

Gamma crystals containing more than 41 per cent. of tin have the peculiarity that, in cooling, they break up into solid Cu_3Sn and a liquid. Between 57 per cent. of tin and 93 per cent., the first solid that forms when the liquid alloy begins to solidify consists of crystals of Cu_3Sn; but when the temperature falls to 400° C. these crystals become unstable, and a reaction takes place between them and the liquid, which results in their partial transformation into a body that is nearly, or quite, pure CuSn. Between 93 per cent. and 99 per cent. of tin the substance CuSn is the first body formed during solidification. Between 99 per cent. and 100 per cent. tin appears to crystallise first.

Assuming the alloys to have been cooled with sufficient slowness, we may summarise their condition at ordinary temperatures as follows:—

0 to 9 per cent. of tin.

A uniform solid solution (Alpha) of copper containing tin, or, more probably, containing a compound, in solution.

9 to 25·5 per cent. of tin.

A complex of large crystals of Alpha in a minute eutectic of Alpha and Cu_4Sn.

25·5 to 32 per cent. of tin.

The same complex, but containing the Cu_4Sn in the larger crystals, and the Alpha only in the minute eutectic. At 32 per cent. the alloy is pure Cu_4Sn.

32 to 38·5 per cent. of tin.

A complex of Cu_4Sn and Cu_3Sn, or of two solid solutions of these substances. At 38·5 per cent. the alloy is pure Cu_3Sn.

38·5 to 93 per cent. of tin.

Large crystalline plates of Cu_3Sn coated with a body that is almost pure CuSn, the whole being immersed in a eutectic of this body and tin.

93 to 99 per cent. of tin.

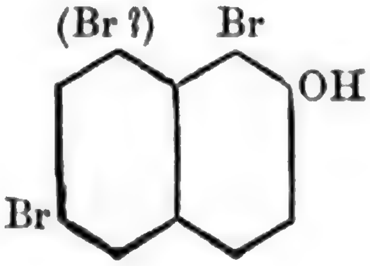
Large crystals of CuSn in a eutectic of this body and tin.

99 to 100 per cent. of tin.

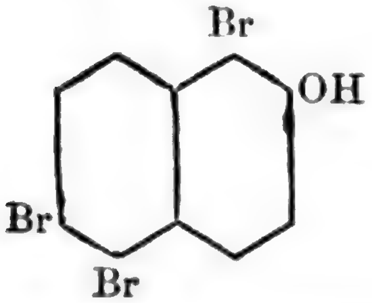
Large crystals of tin in the same eutectic.

Isomeric Naphthalene Derivatives.—Report of the Committee, consisting of Professor W. A. TILDEN *(Chairman), and* Dr. H. E. ARMSTRONG *(Secretary).* *(Drawn up by the Secretary.)*

SINCE the last report was written, the behaviour has been studied of the two tri-bromo-β-naphthols, Nos. 1 and 2, at the ordinary temperature, towards an excess of bromine in presence of aluminium bromide. Each has given two penta-bromo-β-naphthols, the structure of which at once follows from the nature of the quinones derived from them, and the behaviour of the latter on oxidation. The results obtained can only be explained by assuming that the tri-bromo-β-naphthol, No. 2, which was provisionally represented as

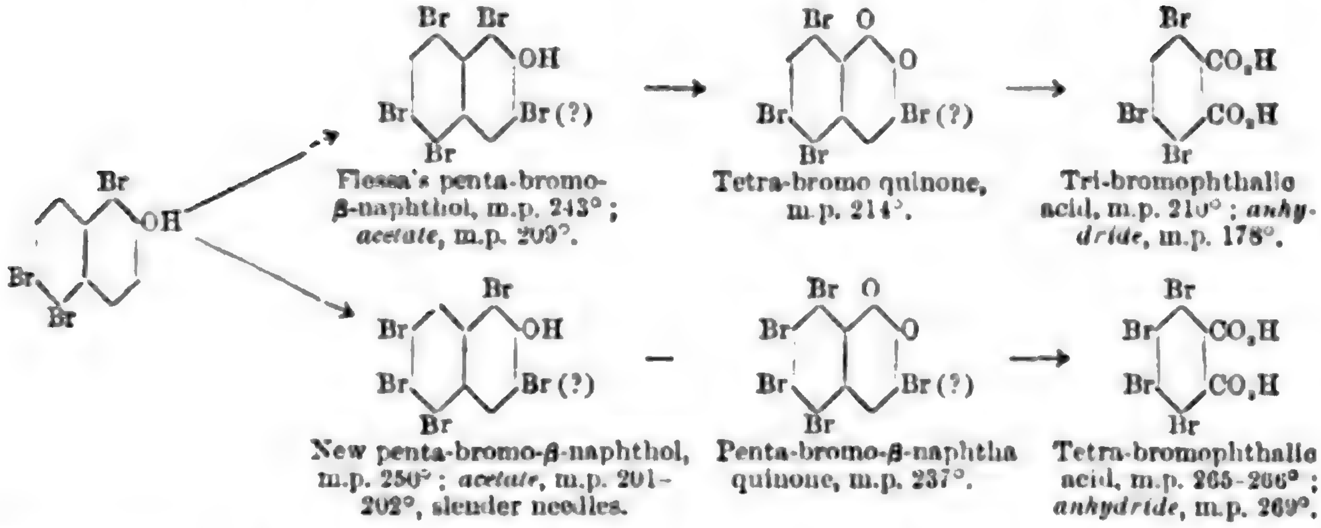


is in reality



It follows, therefore, that the new di-bromophthalic acid (m.p. 195–196°, anhydride, 147°·5) derived from this tri-bromo-β-naphthol by oxidation, is a 3 : 4 *di-bromophthalic acid.*

The following scheme illustrates the results obtained :


Flessa's penta-bromo-β-naphthol, m.p. 243°; *acetate*, m.p. 209°.

Tetra-bromo quinone, m.p. 214°.

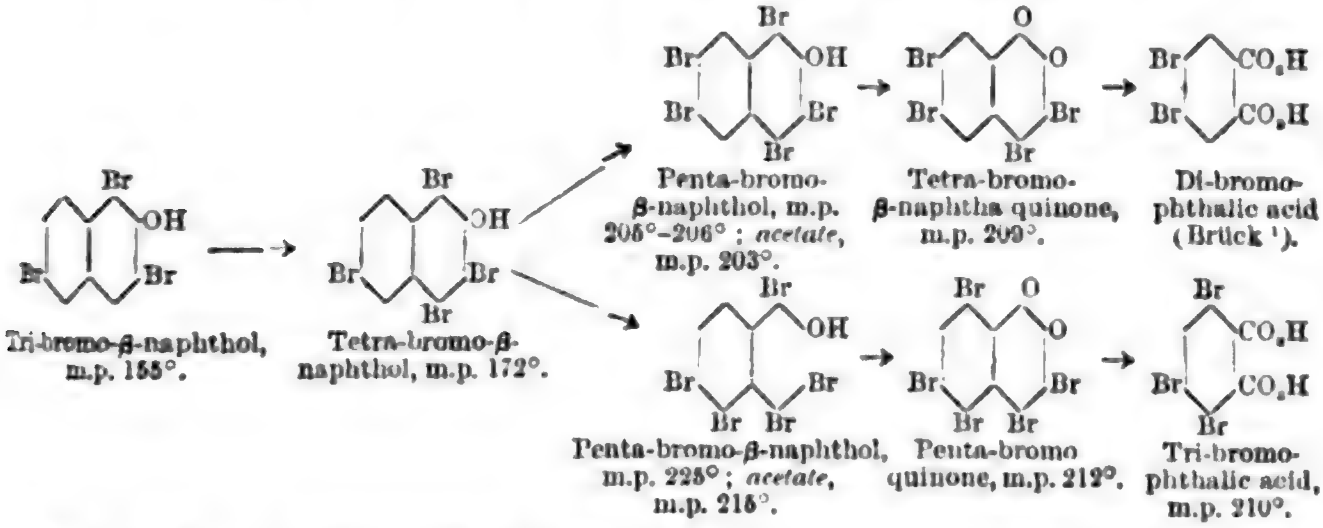
Tri-bromophthalic acid, m.p. 210°; *anhydride*, m.p. 178°.

New penta-bromo-β-naphthol, m.p. 250°; *acetate*, m.p. 201–202°, slender needles.

Penta-bromo-β-naphtha quinone, m.p. 237°.

Tetra-bromophthalic acid, m.p. 265–266°; *anhydride*, m.p. 269°.

The nature of the two penta-bromo-β-naphthols obtained as ultimate products on brominating 1 : 3 : 6-tri-bromo-β-naphthol is established by the fact that they are both formed on brominating 1 : 3 : 4 : 6-tetra-bromo-2-naphthol (m.p. 172°), and the following considerations :—


Tri-bromo-β-naphthol, m.p. 155°.

Tetra-bromo-β-naphthol, m.p. 172°.

Penta-bromo-β-naphthol, m.p. 205°–206°; *acetate*, m.p. 203°.

Tetra-bromo-β-naphtha quinone, m.p. 209°.

Di-bromophthalic acid (Brück [1]).

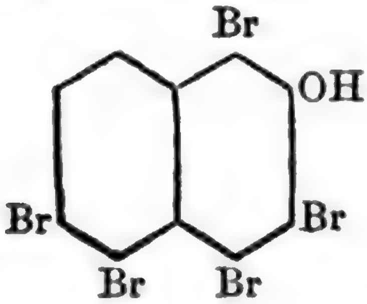
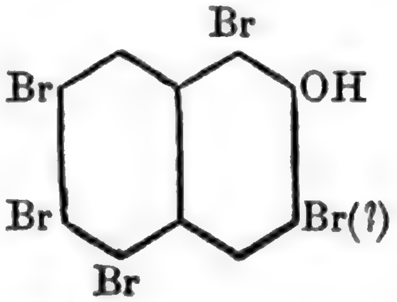
Penta-bromo-β-naphthol, m.p. 225°; *acetate*, m.p. 215°.

Penta-bromo quinone, m.p. 212°.

Tri-bromophthalic acid, m.p. 210°.

Flessa has previously[2] described the penta-bromo-naphthol melting at 243° as melting at 237°, and the derived tetra-bromo-β-naphtha quinone (m.p. 214°) as melting at 164°; but his quinone separated from all solvents only in 'crystalline granules,' whereas the substance melting at 214° forms magnificent flattened needles. Flessa's tri-bromophthalic acid melted at 191° and the anhydride at 157°; whereas the acid from the quinone melting at 214° melts at 210°, and its anhydride at 178°. The structure of this acid, which has not hitherto been established, follows from the results represented in the above schemes; it is 3 : 4 : 6 *tri-bromophthalic acid.*

It is of great interest that whereas two of the penta-bromo-β-naphthols give tetra-bromo-β-naptha quinones in the normal manner, when the bromo-nitro-keto compounds are decomposed by boiling with glacial acetic acid, two, viz.—


and


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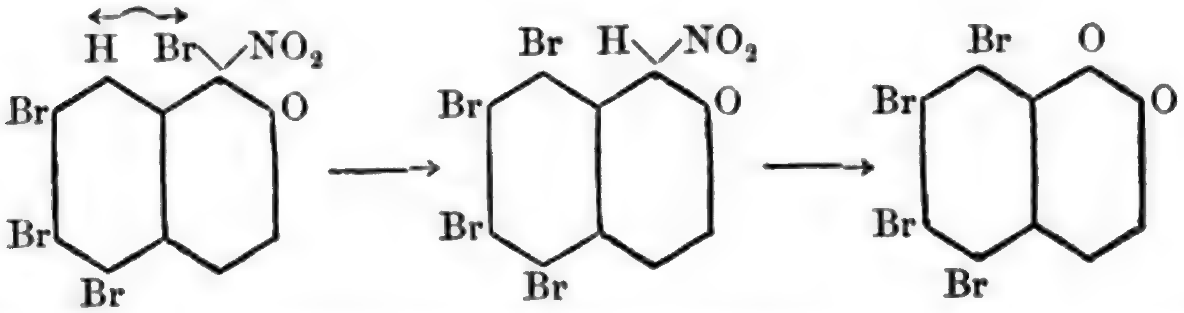
[1] Brück, *Ber.*, 1901, 2741; acid, m.p. 211–213°; anhydride, m.p. 212–213°; monomethyl salt, m.p. 81°.

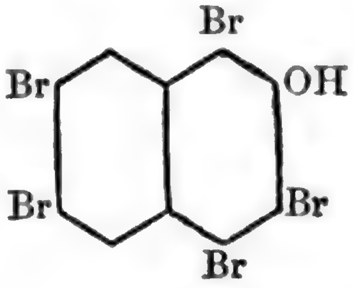
[2] *Ber.*, 17, 1479.

give penta-bromo-β-naphtha quinones under similar conditions; in these cases position 8 is unoccupied, and a transference of bromine takes place from position 1, *e.g.*,

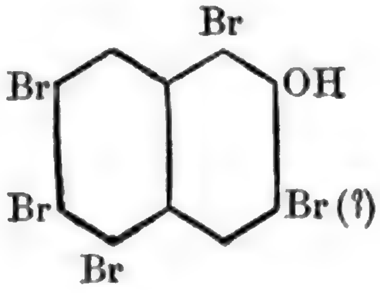


That a direct transference of bromine is effected, and that the product is not formed by bromination of a tetra-bromo quinone formed in the first instance, is proved by two facts: (1) that nearly a theoretical amount is obtained, showing that none of the bromine can be eliminated as hydrogen bromide; (2) that the crude product is pure, showing the entire absence of a tetra-bromo quinone. It is to be supposed that if rebromination were to occur, a mixture of tetra-bromo and penta-bromo quinones would be formed, as a mixture of 6-bromo and 4 : 6-dibromo-β-naphtha quinones is obtained on decomposing the nitro-keto compound of 1 : 6-di-bromo-β-naphthol.

Such a transference of bromine occurs only in the case of the penta-bromo-naphthols, and has not been observed in the case of lower brominated naphthols, in which position 8 is unoccupied. It should be noted that whilst this position is free in

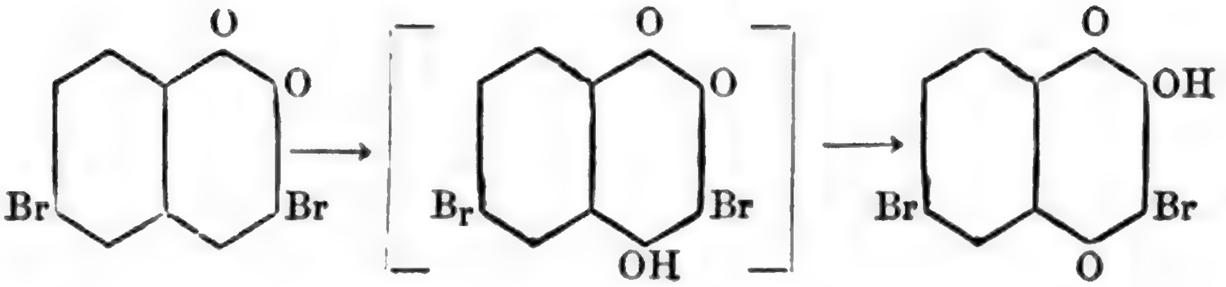


the bromine atom in position 7 apparently prevents the transference of bromine into position 8, although in the case of



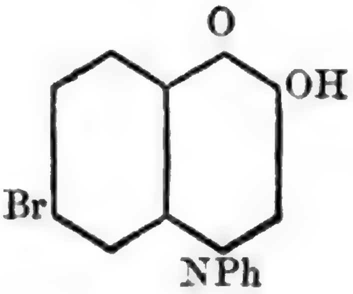
the presence of a bromine atom in position 7 does not prevent the formation of a penta-bromo quinone.

The properties of 3 : 6-di-bromo-β-naphtha quinone have been more fully studied during the year. This substance is remarkable inasmuch as it is far more unstable than any of the other brominated quinones. When kept in the dry state for several months it is transformed by atmospheric oxidation into 3 : 6-di-bromo-2-hydroxy-1 : 4-naphtha quinone.

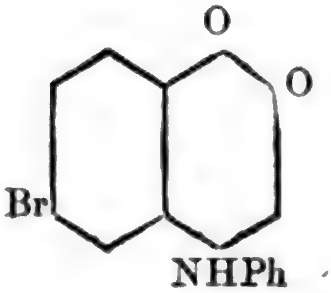


When its solution in ethylic acetate is exposed to light and air for several days another remarkable change occurs, the quinone being transformed into a brick-red crystalline substance, insoluble in all solvents, which has the composition, $C_{20}H_7Br_3O_4$ ($C=43{\cdot}55$, $H=1{\cdot}28$, $Br=43{\cdot}54$, $O=11{\cdot}61$; *found*, $C=43{\cdot}83$, $H=1{\cdot}74$, $Br=43{\cdot}07$, $O=11{\cdot}36$ per cent.).

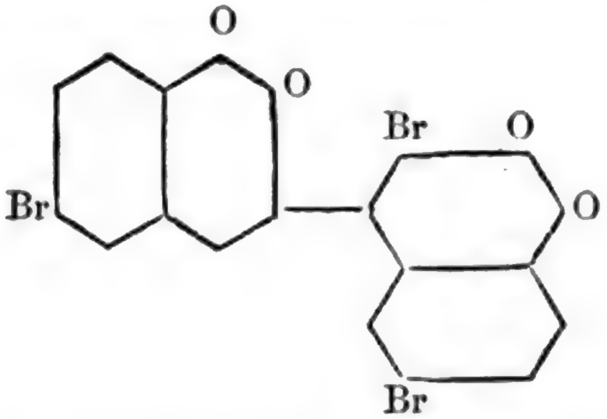
Taking into account the fact that the bromine atom in position 3 of the quinone is very easily removed from the nucleus, as in the production of



—isodynamic form of



—by the action of aniline; and also the reactivity of the hydrogen in position 4 (oxidation by atmospheric oxygen), it may be supposed that the condensation product is a di-naphthyl di-quinone,



The behaviour of 3 : 6-di-bromo-β-naphtha quinone under the influence of light and various solvents, and under the action of alkalis, is being investigated.

Isomorphous Sulphonic Derivatives of Benzene.—Third Report of the Committee, consisting of Professor H. A. MIERS (*Chairman*), Dr. H. E. ARMSTRONG (*Secretary*), Dr. W. P. WYNNE, *and* Mr. W. J. POPE. (*Drawn up by the Secretary.*)

THE crystallographic study of the 1 : 3 : 5 series, the *second* of the three series of sulphonic chlorides and bromides to be derived from the 1 : 3-dichloro-, chlorobromo- and dibromo-benzenes examined thus far, has been practically completed by Dr. Jee during the past year. The results are even more striking than those obtained in the case of the 1 : 3 : 4 series, as there is evidence that the compounds constitute not merely an iso*tri*morphous group, as in the latter case, but an iso*tetra*morphous group, as shown in the following table :—

	Orientation			Crystallographic Systems			
	1	3	5	Anorthic	Monosym	Monosym	Anorthic
1	Cl	Cl	SO_2Br	Stable	Stable	—	—
2	Cl	Br	SO_2Br	—	Stable	—	—
3	Br	Br	SO_2Br	—	Stable	Labile	—
4	Br	Br	SO_2Cl	—	—	Stable	—
5	Br	Cl	SO_2Cl	—	—	Stable	—
6	Cl	Cl	SO_2Cl	—	—	—	Stable
				α-series	β-series	γ-series	δ-series

In this series the dibromobenzenesulphobromide has again been the means of formulating the relationships between the various terms, having been obtained in two distinct polymorphic forms. But in comparison with the 1 : 3 : 4 series the order of stability is reversed, the transition temperature becoming lower in passing down the series.

It is proposed to submit an account of the results obtained in the case of the 1 : 4 : 2(SO_3H), 1 : 3 : 4(SO_3H), and 1 : 3 : 5(SO_3H) series to the Royal Society in the autumn.

The third series of the 1 : 3 derivatives, in which the sulphonic group is between the halogens, has yet to be examined. Very great difficulty has been experienced in preparing the necessary material, but methods have now been devised which promise success. Thus diorthobromobenzenesulphonic acid has been prepared from diorthobromaniline by Gattermann's sulphinic-acid method. Unfortunately, the corresponding dichlor- and chlorobromaniline are not at present available, and therefore other methods of preparing the dichlor- and chlorobrom acid need to be devised. Apparently these will be obtainable from the dimeta-derivatives of aniline.

A complete series of 1 : 2 : 4(SO_3H) derivatives has been prepared, and their crystallographic study will now be undertaken. To complete the investigation, so that it shall comprise all the series derivable from the dichloro-, dibromo- and chlorobromo-benzenes, only the 1 : 2 : 3 (SO_3H) series has to be prepared. This, again, is a matter of considerable difficulty, requiring special investigation.

Progress has been made in extending the investigation to the comparison of the effect produced by homologous hydrocarbon radicles, and also in contrasting corresponding sulphur and oxygen compounds.

Our Present Knowledge of Aromatic Diazo-compounds.

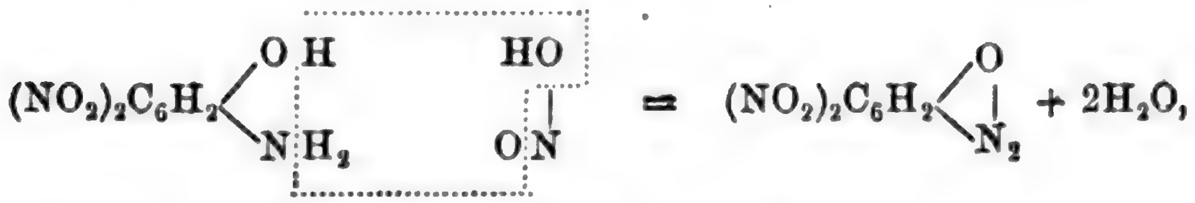
By GILBERT THOMAS MORGAN, *D.Sc.*, *F.I.C.*

[Ordered by the General Committee to be printed *in extenso.*]

THE aromatic diazo-compounds, which were originally discovered by the classical investigations of Griess,[1] have proved to be substances of the utmost value in the development of synthetical chemistry, both from the scientific and the industrial standpoints. The starting-point of these far-reaching researches was a comparative study of asparagine and picramic acid. These substances, which in 1858 were assumed to be compounds of a similar type, behaved quite differently towards nitrous acid, asparagine losing the whole of its nitrogen, whilst picramic acid exchanged three of its hydrogen atoms for one of nitrogen, giving rise to the earliest known diazo-compound—namely, dinitrophenoldiazo-oxide.

It is interesting to notice at this stage that, although the elimination of aminic nitrogen by the action of nitrous acid is characteristic not only of asparagine but also of the majority of aliphatic amino-compounds, yet the preparation of aliphatic diazo-derivatives has been accomplished, and the new field opened up by the discovery of ethyl-diazo-acetate[2] has yielded a rich harvest culminating in the isolation of hydrazine, hydrazoic acid, and diazo-methane. These important contributions to the chemistry of nitrogen will not, however, be further discussed in this report, which is restricted to a consideration of the aromatic diazo-compounds, a class of substances derived from the hydrocarbons of coal tar.

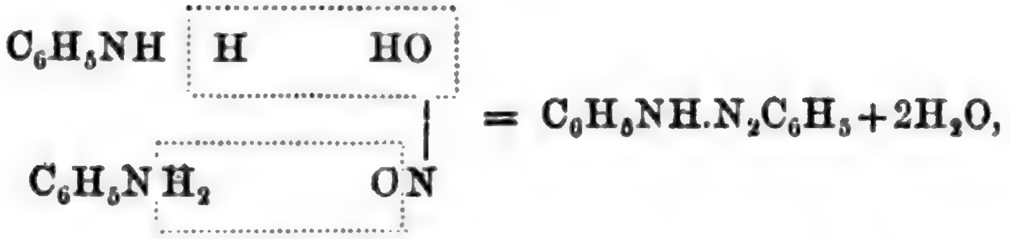
The action of nitrous acid on picramic acid is now interpreted in the following manner,



$$(\mathrm{NO_2})_2\mathrm{C_6H_2}<\begin{matrix}\mathrm{O\;H} & & \mathrm{HO}\\ & & |\\ \mathrm{N\;H_2} & & \mathrm{ON}\end{matrix} = (\mathrm{NO_2})_2\mathrm{C_6H_2}<\begin{matrix}\mathrm{O}\\ |\\ \mathrm{N_2}\end{matrix} + 2\mathrm{H_2O},$$

the product being regarded either as the internal salt or the *eso*-anhydride of dinitrophenoldiazo-hydroxide $(NO_2)_2C_6H_2(OH)N_2OH$.[3]

Griess next extended the investigation to aniline, with the result that diazoaminobenzene was produced,



$$\begin{matrix}\mathrm{C_6H_5NH\;\;H} & & \mathrm{HO}\\ & & |\\ \mathrm{C_6H_5N\,H_2} & & \mathrm{ON}\end{matrix} = \mathrm{C_6H_5NH.N_2C_6H_5+2H_2O},$$

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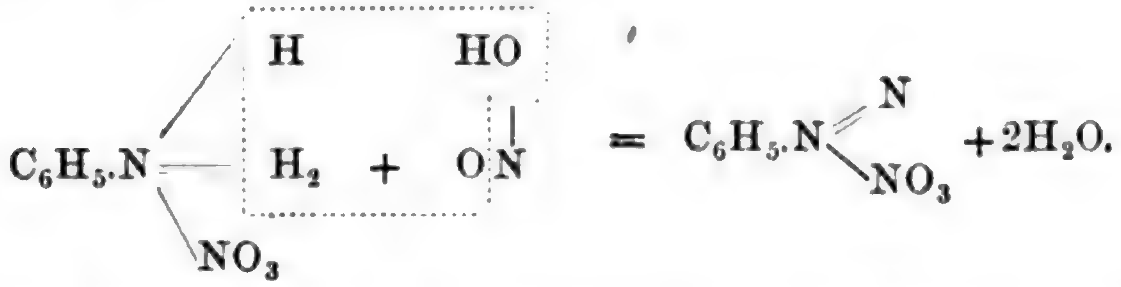
[1] *Annalen*, 1858, **106**, 123; 1860, **163**, 201; 1866, **137**, 39.

[2] Curtius, *Ber.*, 1883, **16**, 2230.

[3] Hantzsch, *Ber.*, 1896, **29**, 1526.

and a subsequent modification of the experimental conditions led to the discovery of benzenediazonium nitrate,



$$C_6H_5.N\begin{cases}H\\H_2\\NO_3\end{cases} + \begin{matrix}HO\\ |\\ ON\end{matrix} = C_6H_5.N\begin{matrix}/\!\!/ N\\ \backslash NO_3\end{matrix} + 2H_2O.$$

These three substances, the *eso*-anhydride, the diazoamine, and the diazonium salt, each containing a diazo-complex, N_2, attached to one aromatic nucleus, are typical examples of three important classes of aromatic diazo-compounds.

The process of converting the salt of a primary aromatic amine into the corresponding diazonium derivative is termed diazotisation, and this important operation may be suitably considered under a separate heading.

I. *The Preparation and Practical Application of Diazo-compounds.*

A. *The Diazo-reaction.*

Benzenediazonium nitrate, the substance formed by the action of nitrous fumes on a cold aqueous solution of aniline nitrate, was found to be a highly explosive salt readily soluble in water or alcohol. On account of these properties the isolation of the salt and the corresponding chloride and sulphate is a somewhat difficult and dangerous operation, and for many years the properties of these substances were studied in the solutions obtained by the action of the alkali nitrites on the primary aromatic base dissolved in excess of cold dilute acid. It has been found by colorimetric and electrolytic determinations of the velocity of this reaction that, in the absence of disturbing influences, all the aromatic amines are diazotised at approximately the same rate.[1]

It is however sometimes necessary to operate with the dry diazonium salts, and these may be prepared by the action of amyl nitrite on solutions of the salts of the amines in absolute alcohol,[2] or glacial acetic acid.[3]

Excess of acid should be avoided in these preparations, for the diazonium chlorides derived from the halogen-substituted anilines combine with hydrogen chloride, forming acid salts of the types RN_2Cl, HCl and $3RN_2Cl$, HCl,[4] these products being less stable than the normal salts themselves.

Bamberger showed that pure benzenediazonium chloride, when dissolved in water, gives a neutral reaction and differs in this respect from aniline hydrochloride, the solution of which is acid, owing to the hydrolytic dissociation of the salt. This result indicates that the strength of the diazonium base is much greater than that of the corresponding primary aromatic amine.

Griess found that the introduction of a diazonium salt into the alkaline solution of a phenol resulted in the formation of an intensely coloured substance containing the diazo-complex N : N, attached to a second aromatic nucleus,

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[1] Hantzsch and Schümann, *Ber.*, 1899, **32**, 1691; 1900, **33**, 527.

[2] Knoevenagel, *Ber.*, 1890, **23**, 2094; Bamberger, *Ber.*, 1896, **29**, 446.

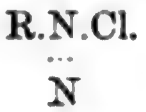
[3] Hantzsch, *Ber.*, 1897, **30**, 92; 1901, **34**, 3337.

[4] *Ber.*, 1897, **30**, 1148 and 1153.

$$C_6H_5N_2Cl + HC_6H_4OH = C_6H_5N_2.C_6H_4OH + HCl.$$

These products, which are called azo-compounds, are also produced either by the reduction and coalescence of two molecules of a nitro-compound, or by the condensation of the nitroso-compounds with the primary amines.[1]

On account of their condensation to form azo-compounds and their ready reduction to hydrazines, the diazonium salts were for many years assumed to have the constitution R.N : N.Cl, a formula which was suggested by Kekulé, although Strecker, Erlenmeyer, and Blomstrand had at different times advocated the claims of the symbol



$$\begin{array}{l} R.N.Cl. \\ \ \ \ \vdots \\ \ \ \ N \end{array}$$

According to the former view, which generally prevailed until 1894, the diazonium bases are substances of the oxime type RN : NOH, and this formula, which satisfactorily accounts for the fact, first noticed by Griess, that benzenediazonium hydroxide forms a potassium derivative, is not opposed to the general behaviour of these bases and their salts when employed in the various synthetical operations which engrossed the attention of investigators in this field until the close of the period now under review.

The synthetical application of the diazonium salts will be considered in the next section, since it does not necessarily involve any discussion as to their precise configuration.

B. *Diazo-compounds as Agents in Chemical Synthesis.*

1. *Replacement of NH_2 by Cl, Br, I, CN, CNO, or CNS.*—Griess's researches on the production of the halogen derivatives of the aromatic hydrocarbons are now only of historical interest, since the methods commonly employed at the present time are due to Sandmeyer[2] and to Gattermann.[3] The latter of these investigators also extended the scope of this synthetical process by demonstrating that the cyano (CNO) and thiocyano (CNS) radicles could also be introduced into the aromatic nucleus by the use of the appropriate diazonium salt.

The course of the reaction between diazonium derivatives and cuprous salts (Sandmeyer) or copper powder (Gattermann) has been recently reviewed by Hantzsch,[4] whose conclusions may be summarised as follows:—

The course of the Sandmeyer reaction is not a simple one, and the final result is due to the simultaneous effect of three concurrent actions: (i) the formation of a labile diazonium cuprous double salt, which subsequently undergoes decomposition in such a manner that the radicle originally attached to copper migrates to the aromatic nucleus; (ii) a catalytic action, which becomes the main reaction when copper powder is employed, whereby nitrogen is eliminated from the diazo-salt, so that the acid radicle becomes directly attached to the aromatic nucleus; (iii) the formation of azo-compounds, which is accompanied by the oxidation of the cuprous salt to the cupric condition.

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[1] C. Mills, *Trans.*, 1895, **67**, 925.

[2] *Ber.*, 1884, **17**, 2650.

[3] *Ber.*, 1890, **23**, 1218; 1892, **25**, 1074.

[4] *Ber.*, 1900, **33**, 2544.

The concurrent effect of the first two reactions was demonstrated by subjecting dry *p*-bromobenzenediazonium bromide to the action of cuprous chloride dissolved in methyl sulphide. The product consisted chiefly of *p*-bromochlorobenzene mixed with a little *p*-dibromobenzene.

$$\text{(i)}\ 2BrC_6H_4N_2Br + Cu_2Cl_2 = Cu_2Br_2 + 2N_2 + 2C_6H_4ClBr.$$
$$\text{(ii)}\ BrC_6H_4N_2Br = N_2 + C_6H_4Br_2.$$

Cuprous bromide and *p*-bromobenzenediazonium chloride yielded *p*-dibromobenzene containing a little *p*-bromochlorobenzene. In both cases the first reaction predominates, and it may, under certain conditions, prevail to the almost complete exclusion of the second. Cuprous iodide, for example, gave rise to iodo-derivatives only, with various diazonium chlorides and bromides, and on the other hand the interaction of cuprous chloride and benzenediazonium iodide furnished chlorobenzene unaccompanied by iodobenzene.

2. *Replacement of NH_2 by NO_2.*—The introduction of nitroxyl through the agency of the diazonium salt was first indicated by Sandmeyer, and further exemplified by Hantzsch (*loc. cit.*) in the following experiments:—

(i) The crystalline double salt $Hg(NO_2)_2, 2C_6H_5N_2.NO_3$ (melting-point 76°), obtained by mixing solutions of benzenediazonium nitrate and potassium mercuric nitrite, decomposes on boiling with water yielding phenol and nitrophenol, but when treated with copper powder it furnishes a quantitative yield of nitrobenzene. (ii) The diazonium sulphates, when mixed with a freshly prepared suspension of cupro-cupric sulphate and treated with excess of an alkali nitrite, give rise to the corresponding nitro-derivatives; 2 : 4 : 6-tribromobenzenediazonium sulphate, for example, gives a 65 per cent. yield of 1-nitro-2 : 4 : 6-tribromobenzene.

β-nitronaphthalene, a substance prepared with considerable difficulty by other processes, is produced from β-naphthylamine to the extent of 25 per cent. by this method, whereas Sandmeyer, who employed cuprous oxide and the diazonium nitrite, obtained only 7 per cent.[1]

3. *Formation of Conjugated Systems R.R or R.N : N.R.*—The third reaction signalised by Hantzsch may be rendered more apparent by reversing the usual order of mixing and adding the cuprous chloride dissolved in hydrochloric acid to the cold solution of the diazonium salt. Under these conditions, aniline, *o*-chloroaniline and the *o*- and *p*-toluidines give rise to appreciable quantities of azo-compounds. The nitrated amines, however, behave very differently, yielding diphenyl-derivatives, this result being obtained with the three nitranilines, *o*-nitro-*p*-chloroaniline and *o*-nitroaniline-*p*-sulphonic acid.

$$2NO_2C_6H_4N_2Cl + Cu_2Cl_2 = NO_2C_6H_4.C_6H_4NO_2 + N_2 + 2CuCl_2.$$ [2]

This type of condensation is also brought about by the use of cuprous oxide in ammoniacal or hydroxylamine solution.[3]

4. *Introduction of the Sulphonic Radicle SO_3H.*—The replacement of NH_2 by SH was first accomplished by Leuckart,[4] who treated the

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[1] *Ber.*, 1887, **20**, 1497.

[2] Ullmann and Forgan, *Ber.*, 1901, **34**, 3802; Niementowski, *ibid.*, 3325.

[3] *Annalen*, 1902, **320**, 122.

[4] *Journ. prakt. Chem.* [2], **41**, 218.

diazonium salt with an alkali xanthate and hydrolysed the resulting aromatic xanthate, thus obtaining either the thiophenol or the disulphide produced by oxidation. Either of these products yields the corresponding sulphonic acid on treatment with alkaline permanganate solution.[1]

The production of sulphinic acids by the direct action of sulphurous acid on diazonium salts appears to have been first observed by Müller and Wiesinger.[2] A simple process, due to Gattermann,[3] was accidentally discovered during an investigation of *o*-methoxybenzenediazonium chloride, when it was found that this salt on treatment with sulphurous acid yielded a diazonium sulphite which, on mixing with copper powder, evolved nitrogen giving rise to the corresponding sulphinic acid, this product being subsequently oxidised by means of permanganate solution.

In general, the reaction takes place most readily with the diazonium sulphate, a cold solution of this salt in a large excess of dilute sulphuric acid being saturated with sulphur dioxide and finally treated with copper powder,

$$RN_2HSO_4 \rightarrow RN_2SO_3H \rightarrow N_2 + RSO_2H.$$

In the case of the diazotised naphthylamines it is better to add their solutions to the mixture of reduced copper and sulphurous acid.

These processes for the production of sulphonic acids have not, however, been successfully applied to the diazonium salts derived from the nitrated aromatic amines.

5. *Replacement of the Diazo-radicle by Hydrogen.*—The method originally employed for the elimination of the diazo-radicle consisted in boiling the diazonium chloride with absolute alcohol; this operation does not, however, invariably give the required result, and Hantzsch[4] has accumulated evidence in support of the view that the normal decomposition of a diazonium salt by an alcohol leads to the production of an alkyl phenoxide. Benzenediazonium chloride or sulphate when boiled with methyl alcohol yields anisole unaccompanied by benzene. Increase in the molecular weight of the alcohol or the accumulation of negative substituents in the aromatic nucleus diminishes the yield of ether and augments that of the hydrocarbon. The benzenediazonium salts, when treated with ethyl alcohol, yield phenetole and a trace of benzene; their chloro- and bromo-derivatives, when boiled with this reagent, give halogenated benzenes but no substituted ethers, whereas methyl alcohol converts them into mixtures consisting chiefly of the substituted phenoxide and a small quantity of the halogenated hydrocarbon. Numerous examples of this reaction will be found in the work of Remsen and his pupils.[5]

In the case of diphenyltetrazonium chloride the elimination of the diazonium radicle takes place in two stages,

$$ClN_2.C_6H_4.C_6H_4N_2Cl \rightarrow C_6H_5.C_6H_4N_2Cl \rightarrow C_6H_5.C_6H_5.$$ [6]

The reversion to the parent hydrocarbon is more readily effected by the process introduced by Baeyer and Pfitzinger,[7] which consists in reducing the diazonium salt to the hydrazine with stannous chloride, and subsequently removing the hydrazino-radicle $NH.NH_2$ by boiling with cupric sulphate solution.

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[1] F. Bayer & Co., *D.R-P.*, 70286; Wynne and Bruce, *Trans.*, 1898, **73**, 738.

[2] *Ber.*, 1879, **12**, 1348.

[3] *Ber.*, 1899, **32**, 1136.

[4] *Ber.*, 1901, **34**, 3337.

[5] *Amer. Chem. J.*, **15**, 105; **19**, 531, 547, 561.

[6] *Ber.*, 1898, **31**, 479.

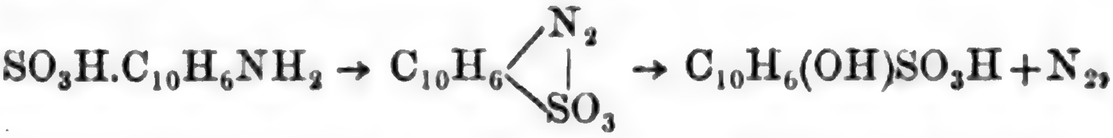
[7] *Ber* 1885, **18**, 90, 786 (compare Wynne and Bruce, *loc. cit.*).

Sodium stannite has been recommended as an agent for reducing the diazonium salt to the hydrocarbon[1]: $C_6H_5N_2Cl+NaOH+Na_2SnO_2=C_6H_6+N_2+Na_2SnO_3+NaCl$.

Mai has recently found that *p*-toluenediazonium chloride, when added to a strong solution of hypophosphorous acid gives rise to toluene, the yield being 67 per cent. Benzenediazonium chloride yields a mixture of benzene (two parts) and diphenyl (1 part), whilst diazotised benzidine and α-naphthylamine furnish diphenyl and naphthalene respectively.[2]

6. *Substitution of NH_2 by OH.*—The replacement of NH_2 by OH, although an extremely important synthetical operation, can hardly be included amongst the modern developments of the application of diazonium salts, inasmuch as the process still employed, which consists in boiling the aqueous solution of the diazonium salt, is a legacy derived from Griess's pioneering researches.

The manufacture of the 1 : 4- and 1 : 8- α-naphtholsulphonic acids from the corresponding amino-compounds



$$SO_3H.C_{10}H_6NH_2 \rightarrow C_{10}H_6\left\langle\begin{matrix}N_2\\ |\\ SO_3\end{matrix}\right. \rightarrow C_{10}H_6(OH)SO_3H+N_2,$$

and the production of 1 : 8-dihydroxynaphthalene 3 : 6-disulphonic acid (chromotrope acid), may be cited as examples of the application of this process.

7. *Miscellaneous Substitutions.*—There are several other modes of reaction which, although of less importance from the synthetical point of view, are nevertheless of interest as indicating the extremely reactive character of the diazonium salts.

(i) The amino groups in certain azo-derivatives of β-naphthylamine are replaced by the acetoxy-radicle when these substances are diazotised in warm glacial acetic acid,[3] and Orndorff[4] showed that this reaction may be generally employed in the production of aromatic acetates.

(ii) A remarkable example of intramolecular change was noticed by Hantzsch in studying the chloro- and bromo-diazonium thiocyanates.[5] These salts, when dissolved in alcohol containing a trace of hydrochloric acid, become converted into the isomeric thiocyanobenzenediazonium chlorides and bromides,

$$ClC_6H_4.N_2.CNS \rightarrow CNS.C_6H_4.N_2.Cl$$

This change takes place only when the halogen atom is situated in an ortho- or para-position with respect to the diazonium group; transformation does not occur in the case of *m*-chlorobenzenediazonium thiocyanate.

The extent to which this rearrangement is possible is best indicated by the limiting case, 2 : 4 : 6-tribromobenzenediazonium sulphate in the presence of excess of potassium thiocyanate actually giving rise to 2 : 4 : 6-trithiocyanobenzenediazonium thiocyanate $(CNS)_3C_6H_2N_2.CNS$.

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[1] Friedländer, *Ber.*, 1889, **22**, 587.

[2] *Ber.*, 1902, **35**, 162.

[3] Meldola and East, *Trans.*, 1888, **53**, 460.

[4] *Amer. Chem. Journ.*, 1888, **10**, 368.

[5] *Ber.*, 1896, **29**, 947; 1898, **31**, 1253.

(iii) Another extremely interesting case of molecular rearrangement is the conversion of the bromodiazonium chlorides into the isomeric chlorodiazonium bromides.[1]

This transformation, which has been studied quantitatively, is a monomolecular change, subject to the following laws :—

1. The bromine atoms undergo replacement only when present in the para- or ortho-position with respect to the diazo-radicle, those in the ortho-position being most readily removed. Metabromo-derivatives are not affected.
2. The ease of transformation increases with the number of bromine atoms present.
3. The transformation constant, calculated from the equation $\kappa = 1/t \log a/(a-x)$, increases with the temperature, and is also influenced by the solvent, having its minimum value in water, and becoming greater as the series of alcohols is ascended.

The diazonium salts containing two bromine atoms are stable when dry, but rapidly undergo conversion in ethyl alcohol ; 2 : 4 : 6-tribromobenzenediazonium chloride becomes transformed even in the dry state.

(iv) Dibenzoylhydrazines $RN(COC_6H_5)N(COC_6H_5)R$ are obtained by treating diazonium salts with an aqueous suspension of benzoyl chloride and copper powder.[2]

C. *Diazo-compounds employed in the Production of Azo-colouring Matters.*

1. *Aminoazo-compounds.*—The action of a diazonium salt on a primary aromatic amine gives rise either to a diazoamine or an aminoazo-compound, according as to whether the diazo-radicle remains attached to the aminic nitrogen, or migrates into the aromatic nucleus. Aniline and its homologues and substitution products yield diazoamines, which are often capable of undergoing rearrangement into aminoazo-compounds, this change being effected either by allowing the diazoamine to remain in alcoholic solution or by warming it with a mixture of the parent base and its hydrochloride. The latter mode of transformation has been studied quantitatively by Goldschmidt and his pupils,[3] with the following results :—

The transformation of diazoaminobenzene into aminoazobenzene in an aniline solution containing aniline hydrochloride is a monomolecular reaction, the velocity of transformation, in moderately dilute solution, being proportional to the temperature and to the amount of catalyst (aniline hydrochloride) but independent of the concentration. Benzenediazoamino-*p*-toluene, when dissolved in aniline containing its hydrochloride, becomes converted into diazoaminobenzene and *p*-toluidine, the resulting diazoamine then undergoing transformation in accordance with the preceding rules.

This conversion takes place more slowly when the diazo-radicle shifts into the ortho-position with respect to the amino-group. The transformation constant of diazoaminobenzene at 45° is 0·081, whereas the value of this coefficient for diazoamino-*p*-toluene is only 0·0095, the solutions employed in both cases being semi-normal.

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[1] Hantzsch, *Ber.*, 1897, **30**, 2334; *Journ. prakt. Chem.*, **27**, 98; and *Ber.*, 1900, **33**, 505.

[2] *Ber.*, 1902, **35**, 1964.

[3] *Ber.*, 1896, **29**, 1369, 1899.

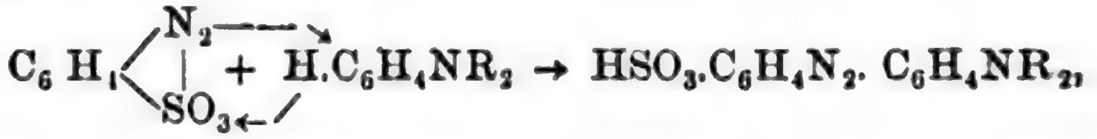
The existence of analogous intermediate diazoamino-compounds and diazohydroxy-derivatives in the commercial azo-colouring matters, has been recently demonstrated by Vaubel.[1]

Although aniline and other benzenoid primary amines give rise to diazoamines when treated with diazonium salts, their dialkyl derivatives containing a free para-position with respect to nitrogen readily furnish azo-compounds of the methyl-orange type. The formation of these colouring matters is governed by the following laws :[2]

(i) The velocity of formation of the aminoazo-compound depends only on the nature of the reagents and not on the concentration.

(ii) In coupling the hydrochloride of a tertiary base with diazobenzene sulphonic acid, the interaction occurs between the diazo-compound and the base set free by the hydrolytic dissociation of its salt.

These laws are deduced from the following facts :—The concentration of the hydrochloride of the base or the diazo-compound has no influence on the velocity of condensation. Excess of hydrochloric acid lessens the velocity. The formation of methyl orange or the corresponding ethylated colouring matter,

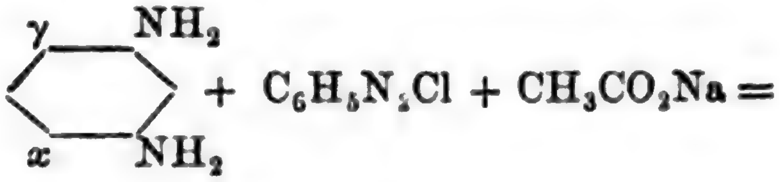


$$C_6H_4\left<\begin{array}{c}N_2\\ |\\ SO_3\end{array}\right. + H.C_6H_4NR_2 \rightarrow HSO_3.C_6H_4N_2.C_6H_4NR_2,$$

when carried out in the presence of different acids (*e.g.*, acetic, mono-, di-, and tri-chloracetic acids and hydrochloric acid), takes place most rapidly with the weakest acid, the velocity decreasing as the affinity constant of the acid increases.

Azo-derivatives of the aromatic *meta*-diamines, although amongst the oldest of the colouring matters, are still manufactured on a large scale for the use of the dyer. Bismarck brown, which was prepared even before the exact nature of the diazo-reaction had been elucidated, is still employed in the arts, and the precise composition of the commercial product has only recently been established by the researches of Täuber.[3]

Chrysoidine, first introduced by Witt,[4] also maintains its position against the newer dyestuffs. Its homologues and substitution products may be readily and quantitatively prepared from any of the derivatives of *m*-phenylenediamine, providing that these substances contain at least one free para-position with respect to an amino-radicle. If this condition is not fulfilled the production of an azo-compound, although still possible if the diamine contains a free ortho-position with respect to nitrogen, is nevertheless very considerably hindered. The formation of azo-derivatives from symmetrically disubstituted primary *m*-diamines has been demonstrated,[5] but the reaction



$+ C_6H_5N_2Cl + CH_3CO_2Na =$

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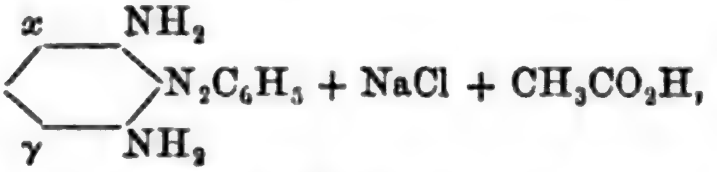
[1] *Zeit. Farben. Textilchem.*, 1902, 1, 3.

[2] Goldschmidt and Merz, *Ber.*, 1897, 30, 670 and 2075

[3] *Ber.*, 1897, 30, 2111, 2899; 1900, 33, 2116

[4] *Ber.*, 1877, 10, 656.

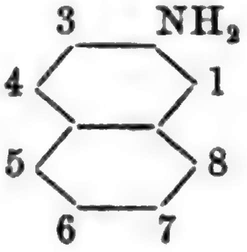
[5] Morgan, *Trans.*, 1902, 81, 86.



$$(x, \gamma\text{-}(NH_2)_2)C_6H_3N_2C_6H_5 + NaCl + CH_3CO_2H,$$

takes place with considerable difficulty, and the yield of azo-compound is small; moreover the complete alkylation of the amino-radicles altogether prevents this condensation.[1]

In the case of the naphthylamines and their sulphonic acids, the formation of ortho- and para-aminoazo-compounds takes place with equal readiness; β-naphthylamine,



however, only yields azo-derivatives when the positions 1 and 8 are unoccupied. The presence of substituent radicles in either of these positions leads to the formation of diazoamines,[2] and there appears to be no tendency for the diazo-group to migrate into position 3.

2. *Hydroxyazo-compounds.*—The formation of benzeneazophenol by the action of benzenediazonium chloride on an alkaline solution of phenol is a typical example of the method of preparing this important class of substances. Goldschmidt (*loc. cit.*) found that the essential reagents in this reaction are the diazo-hydroxide and the phenol set free by the hydrolysis of its alkali-derivative. Excess of alkali hinders the condensation, the velocity of which diminishes as the concentration of the phenol or diazo-compound increases.

Although at first sight the mode of formation of hydroxyazo-compounds seems to leave little room for doubt as to the constitution of the products, yet this point has, for many years, been the subject of considerable controversy. This discussion arose from the fact that certain of these hydroxyazo-compounds can also be prepared by condensing the aromatic hydrazines with quinones; 4-benzene-azo-α-naphthol, for example, can be obtained either from benzenediazonium chloride and α-naphthol, or from phenylhydrazine and α-naphthoquinone. Similarly the corresponding 2-benzene-azo-α-naphthol is produced either as a by-product in the former of these reactions, or by the action of phenylhydrazine on β-naphthoquinone, and the alternative methods of formation may be represented in the following manner:—

(i) Azo-condensation,

$$C_6H_5N_2\boxed{OH + H}C_{10}H_6OH = H_2O + C_6H_5.N_2.C_{10}H_6OH.$$

(ii) Hydrazone condensation,

$$C_6H_5NHN\boxed{H_2 + O}C_{10}H_6O = H_2O + C_6H_5NHN:C_{10}H_6O.$$

Since the two reactions give rise to identically the same substance, it follows that intramolecular rearrangement must have occurred during one or other or both of these condensations. This problem, which was for some years attacked by purely chemical methods,[1] has more recently been approached from the physico-chemical side, but even now the question can scarcely be said to be definitely settled. The cryoscopic determinations made by Auwers and his pupils[2] indicate that only the ortho-hydroxy-azo-compounds are quinone-hydrazones, the para-derivatives being phenolic. Chemical evidence in support of the azo-formula for the para-hydroxy-compounds is furnished by Hewitt,[3] whilst Noelting's results show that these substances may also react as hydrazones.[4]

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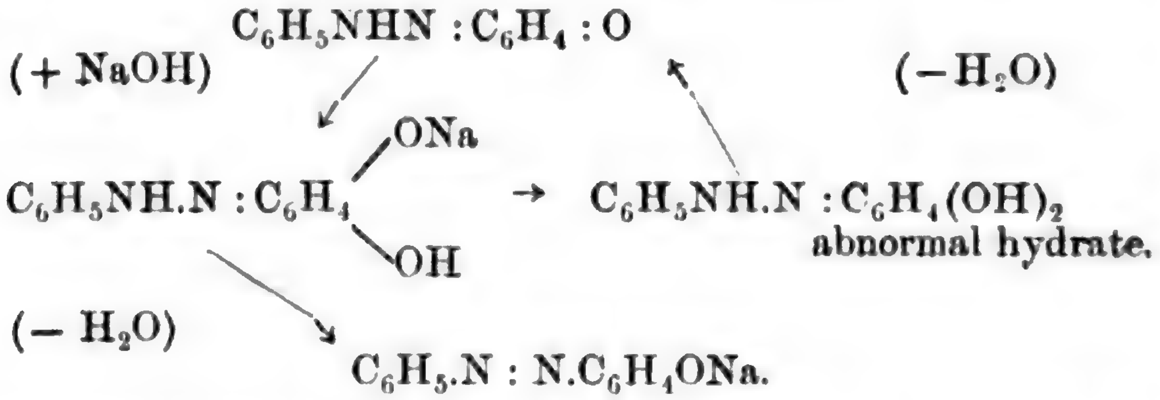
[1] *Trans.*, 1902, **81**, 650.

[2] Witt, *Ber.*, 1888, **21**, 3483; Morgan *Trans.*, 1902, **81**, 91.

The question has again been revived by Hantzsch, who places the hydroxyazo-compounds within the category of pseudo-acids. These are acidic substances which have a configuration differing from that of their salts, tautomeric change taking place during the formation of the metallic derivatives :


$C_6H_5NHN : C_6H_4 : O$
(+ NaOH)
(− H_2O)
$C_6H_5NH.N : C_6H_4$ ONa OH
$C_6H_5NH.N : C_6H_4(OH)_2$
abnormal hydrate.
(− H_2O)
$C_6H_5.N : N.C_6H_4ONa.$

The substance $C_6H_5NNH : C_6H_4 : O$ is a non-electrolyte, and hence its salt, when dissolved, should exhibit hydrolytic dissociation ; this however is not the case, the metallic derivative behaving as the salt of a negatively substituted phenol. The hydrates of the azo-phenols, isolated by Hewitt,[3] contain only half a molecule of water, but the compound $Cl.C_6H_4NH.N : C_6H_3CH_3(OH)_2$ has been obtained[6] which corresponds with the abnormal hydrate required by Hantzsch's hypothesis.

The manufacture of hydroxyazo- and aminoazo-compounds has acquired considerable importance, owing to the fact that the products of the action of diazotised benzidine, tolidine, and *o*-dianisidine on the sulphonic acids of the naphthalenoid amines and phenols have the valuable property of dyeing unmordanted cotton ; a quality which is also shared by the azo-derivatives of primulin and dehydrothio-*p*-tolidine, two amines containing sulphur, which were discovered by Green.[7]

The sodium salt of sulphonated primulin can itself be dyed on cotton, and after being diazotised on the fibre and treated with a solution of a suitable phenol or amine, it gives rise to an insoluble azo-compound which, on account of the method of formation, is called an 'ingrain' colouring matter.

These insoluble azo-compounds may also be produced by first impregnating a textile fabric with a phenol, and then treating the material with the solution of a diazonium salt. It was in the course of an investigation on diazo-compounds employed in the production of these 'ingrain' azo-compounds that Schraube and Schmidt first isolated the so-called '*iso*diazo-compounds.'[1] This important discovery inaugurated a new era of investigation on the diazo-compounds, and led to a revival of the discussion regarding their constitution, a question which had been in abeyance for many years.

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[1] Liebermann, *Ber.*, 1883, **16**, 2858 ; Zincke, *Ber.*, 1884, **17**, 3026 ; 1887, **20**, 3171 ; Meldola, *Trans.*, 1889, **55**, 114, 603.

[2] *Zeit. für Phys. Chem.*, **21**, 355, and *Ber.*, 1900, **33**, 1302.

[3] *Trans.*, 1900, **77**, 99, 712, 810.

[4] *Ber.*, 1887, **20**, 2997.

[5] *Ber.*, 1895, **28**, 799 ; 1898, **31**, 2118.

[6] *Ber.*, 1899, **32**, 3089.

[7] *Trans.*, 1889, **55**, 227.

II. *The Constitution of Diazo-compounds.*

A. *Metallic Diazo-derivatives.*

The alkali *iso*diazo-oxides, discovered by Schraube and Schmidt, are prepared by adding a solution of diazonium salt to a warm concentrated solution of an alkali hydroxide. The presence of negative radicles in the aromatic nuclus of the diazonium salt causes the transformation to take place more readily ; the conversion of *p*-nitrobenzenediazonium chloride is effected, even at —10°, whilst the rearrangement of the unsubstituted diazonium compound requires a very concentrated solution of alkali hydroxide, and a temperature of 130–140°. The more acidic diazo-compounds are transformed even by the action of the alkali carbonates.[2] It was at first supposed that these *iso*diazo-oxides were metallic derivatives of the primary aromatic nitrosamines, the transformation taking place in accordance with the following equation :

$$C_6H_5N_2Cl + 2\,KOH = KCl + H_2O + C_6H_5.NK.NO.$$

This view derived support from the fact that these metallic derivatives showed little or no tendency to yield azo-compounds with alkaline solutions of the phenols ; moreover, they yielded nitrosamines of the secondary amines on alkylation,

$$RNKNO \rightarrow RNCH_3.NO.$$

That the nitrosamine formula is insufficient to account for all the reactions of the *iso*diazo-oxides was soon shown by von Pechmann, who obtained an oxygen ether, $NO_2C_6H_4N_2OCH_3$, from silver iso-*p*-nitrobenzenediazo-oxide ; this methyl derivative has the properties of a diazonium salt, yields azo-compounds with the phenols and a diazoamine with aniline, and it evolves nitrogen on boiling with water, *p*-nitrophenol being simultaneously produced. It therefore follows that the hydroxide corresponding with these metallic derivatives exhibits the phenomenon of tautomerism. On neutralising a suspension of potassium iso-*p*-nitrobenzenediazooxide with a weak acid, a yellow substance is produced, which at first shows little tendency to form azo-compounds with β-naphthol, and its disulphonic acid, but when left in contact with dilute mineral acid, the product slowly dissolves and the soluble compound obtained has all the properties of the original diazonium salt. This change may be indicated in the following manner :

$$NO_2.C_6H_4NK.NO \rightarrow NO_2C_6H_4NH.NO \rightarrow NO_2C_6H_4N_2Cl.$$

This restoration of the capacity for coupling with phenols after acidification was at first considered to be characteristic of *iso*-diazo-derivatives, but the test is not very decisive since the metallic *iso*-diazo-oxides themselves couple with β-naphthol dissolved in alkali hydroxide, providing that the solution is not too alkaline.

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[1] *Ber.*, 1894, **27**, 520; Badische Anilin u. Soda-Fabrik, D.R.-P., 78874, 80263, 81134, 81202.

[2] Schraube and Schmidt, and Badische Anilin u. Soda Fabrik, *loc. cit.*

It was next found that potassium benzenediazo-oxide exists in two modifications, the *iso* form previously mentioned, and the normal form which coupled with the phenols much more readily than its isomeride. This type of isomerism obtains generally amongst the metallic diazo-oxides, but the presence of negative substituents in the aromatic nucleus greatly diminishes the stability of the normal modification. On this account it is usually very difficult to obtain both isomerides in a state of purity.

Isomeric salts have, however, been prepared from diazobenzenesulphonic acid; the normal basic sodium salt, $NaON_2C_6H_4SO_3Na, 4H_2O$, is obtained by working with cooled solutions, whilst the *iso*-salt, which separates in anhydrous crystals, is produced by heating a solution of its isomeride; they are both strongly alkaline and are distinguished by their behaviour towards β-naphthol, the former salt readily coupling whilst the latter exhibits this property to a very slight extent. The corresponding potassium compounds have been isolated, and similar pairs of isomeric alkali salts have also been prepared from *p*-bromodiazobenzene-*o*-sulphonic acid.[1]

Diazo- and Isodiazo-oxides.—When the isomeric diazo-oxides were first investigated there existed a tendency to exaggerate the differences between the isomerides, and they were originally supposed to differ essentially in the following respects:—

(i) Capacity for coupling with phenols or ethyl aceto-acetate and similarly constituted compounds.

(ii) Behaviour towards alkylating, reducing, and oxidising agents.

(iii) Interaction with benzoyl chloride and alkali hydroxides.

Production of Azo-derivatives.—The normal diazo-oxides exhibit the greater tendency to combine with the phenols, but in the case of both isomerides the rate of formation of hydroxyazo-compounds is largely dependent on the nature of the aromatic radicle attached to the diazo-group, and the free isomeric diazo-hydroxides couple with phenols even more readily than their potassium derivatives.[2]

It was at first supposed that the metallic *iso*diazo-oxides did not condense with ethyl aceto-acetate,[3] differing essentially in this respect from the normal derivatives which had long been known to furnish condensation products with the ester,[4] but Bülow subsequently showed that the *iso*diazo-compounds yield mixed aliphatic-aromatic hydrazones or azo-derivatives.[5] This correction, although suggesting the structural identity of the normal and *iso*diazo-oxides, does not assist in deciding between the two formulæ R.N : NOH and R.NH.NO, owing to the uncertainty which still exists with regard to the constitution of the aromatic and mixed condensation products, these substances being regarded by some authorities as azo-derivatives, and by others as hydrazones.

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[1] Hantzsch, *Ber.*, 1895, **28**, 2002; 1900, **33**, 2158; and Gerilowski, *ibid.*, 2317.

[2] Bamberger, *Ber.*, 1898, **28**, 444.

[3] Schraube and Schmidt, *loc. cit.*

[4] Japp and Klingemann, *Ber.*, 1887, **20**, 3398; *Annalen*, **247**, 190; and Claisen and Beyer, *Ber.*, 1888, **21**, 1697.

Ber., 1898, **31**, 3122; 1899, **32**, 197

Alkyl Diazo-oxides.—The action of methyl iodide on the metallic *iso*diazo-oxides indicates that the *iso*diazo-hydroxide itself is a tautomeric substance, for the potassium salt yields a nitrosamine $R.NCH_3NO$, whilst the silver derivative gives rise to an *O*-ether, $R.N:NOMe$, this substance being also produced from the silver derivative of the normal diazo-hydroxide. This result indicates that the isomeric diazo-hydroxides corresponding with the two silver derivatives both have the same structural formula, $R.N:NOH$. These *O*-ethers contain the diazo-radicle $N:N$, for they are all explosive and readily couple with the phenols in alkaline solutions.[1]

Reduction of the Metallic Diazo-oxides.—The members of both series, when treated with sodium amalgam, yield the corresponding hydrazines, provided that the reaction takes place in excess of alkali hydroxide.[2]

Oxidation of the Metallic Diazo-oxides; the Aromatic Diazoic Acids.—Even before the discovery of the *iso*diazo-compounds Bamberger had prepared acidic substances by the oxidation of the diazonium salts in alkaline solutions, and on repeating the experiment with the alkali *iso*diazo-oxides he obtained a larger yield of the oxidation product.[3] These acidic substances, the aromatic diazoic acids, are also obtained either by dehydrating the nitrates of the primary aromatic amines,

$$R.NH_2HNO_3 - H_2O = R.NH.NO_2,$$

or by the direct action of nitric anhydride on these bases,

$$2RNH_2 + N_2O_5 = H_2O + 2RNH.NO_2.$$

They readily undergo molecular rearrangement, yielding nitro-amines, the nitroxyl radicles entering the nucleus either in the ortho- or para-position with respect to the aminic nitrogen.[4] These properties indicate that the diazoic acids are nitramines; nevertheless they behave as tautomeric substances, for whereas their alkali salts give rise to secondary nitramines, their silver derivatives furnish *O*-esters,

$$C_6H_5NHNO_2\left\{\begin{array}{ll}\text{potassium salt} \rightarrow & C_6H_5NCH_3.NO_2 \\ & \text{methylphenylnitramine.} \\ \text{silver salt} \rightarrow & C_6H_5N:NOOCH_3 \\ & \text{methyl benzenediazoate.}\end{array}\right.$$

The methyl *O*-ester, when boiled with a benzene solution of β-naphthol, yields benzene-azo-β-naphthol, this condensation indicating its relationship to the diazo-compounds.

The Isomeric Diazo-oxides and the Schotten-Baumann Reaction.—The normal and *iso*-diazo-oxides, when treated with benzoyl chloride, yield nitrosobenzanilide with equal readiness, provided that the reaction is performed in the presence of a large excess of alkali hydroxide. The amount of benzoyl derivative produced is very small when the mixture is only slightly alkaline, the diminution in yield being greatest in the case of the normal isomeride.[5] This reaction, at first sight, seems to favour the nitrosamine formula for the diazo-oxides

$$C_6H_5NHNO \rightarrow C_6H_5N(NO).COC_6H_5,$$

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[1] Bamberger, *Ber.*, 1895, **28**, 225.

[2] Hantzsch, *Ber.*, 1898, **31**, 340.

[3] *Ber.*, 1894, **27**, 914.

[4] Bamberger, *Ber.*, 1893, **26**, 471; 1894, **27**, 359, 584, 2601.

[5] Hantzsch, *Ber.*, 1897, **30**, 621.

but von Pechmann's experiments[1] indicate that the product is a tautomeric substance behaving also as if it had the formula

$$C_6H_5N : NOCOC_6H_5.$$

Thus, when condensed with sodium β-naphthoxide, it yields benzeneazo-β-naphthol, and on treatment with cold potassium hydroxide solution undergoes hydrolysis, giving rise to potassium benzenediazo-oxide, a certain amount of this salt being also formed during the benzoylation of the *iso*-diazo-oxide.

Blomstrand, who advocated the diazonium formula $C_6H_5.\underset{\substack{\vdots \\ N}}{N}.OK$ for the normal diazo-oxide,[2] supposed that the production of nitrosobenzanilide is due to the transformation of the benzoate $C_6H_5.\underset{\substack{\vdots \\ N}}{N}O.COC_6H_5$; this, however, is not the case, for the ester when prepared from benzenediazonium chloride and silver benzoate does not yield any trace of nitroso-compound under similar experimental conditions.[3]

Synthesis of Isodiazo-oxides.—The oxime formula for the metallic *iso*-diazo-oxides also derives support from the fact that the alkali benzene-*iso*-diazo-oxide is produced by the action of hydroxylamine on nitrosobenzene in alkaline solutions,

$$R.NO + H_2NOH + KOH = R.N : NOK + 2H_2O.$$ [4]

Since the *iso*diazo-oxide may be oxidised to the corresponding benzenediazoate, and reproduced from this substance or its alkyl ester by reduction with sodium amalgam, the cycle of changes may be thus indicated :—

$$\begin{tikzcd}
 & R.N : NOOK \arrow[dr, dashed] \arrow[dl, dashed, bend left] & \\
R.N : NOK \arrow[ur] & & R.N : NOOCH_3 \arrow[ll]
\end{tikzcd}$$

B. Stereo-chemical Relationship of the Isomeric Diazo-oxides.

The behaviour of the isomeric alkali diazo-oxides in the reactions described in the preceding section justifies the belief that the two series are structurally identical, and that the comparatively slight differences between the diazo- and *iso*diazo-derivatives are due to a different spatial arrangement of the radicles associated with the diazo-group, N=N. Accordingly, Hantzsch suggested that this isomerism is comparable with that which obtains among the oximes, the latter kind of isomerism being explained by supposing that the labile and stable modifications contain the associated radicles differently arranged about the complex N=CH in the manner indicated.

$$\text{Stable oxime} \quad \begin{array}{c} R.CH \\ \| \\ HO.N \end{array} \qquad\qquad \text{Labile oxime} \quad \begin{array}{c} R.CH \\ \| \\ N.OH \end{array}$$

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[1] *Ber.*, 1892, **25**, 3199.

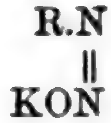
[2] *Journ. prakt. Chem.*, 1896, **54**, 329.

[3] See also Bamberger, *Ber.*, 1897, **30**, 366.

[4] Bamberger, *Ber.*, 1895, **28**, 1218.

The corresponding diazo-oxides would be thus represented :—

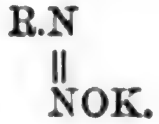
*Syn*diazo-oxide



$$\begin{array}{c}R.N\\ \|\\ KON\end{array}$$

(normal series)

*Anti*diazo-oxide



$$\begin{array}{c}R.N\\ \|\\ NOK.\end{array}$$

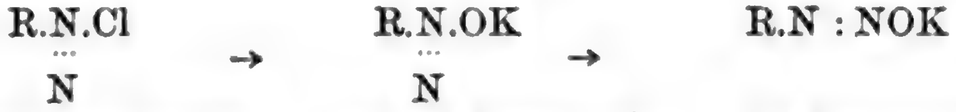
(iso series)

The assumption involved in both cases is the same—namely, that the third affinity of doubly linked trivalent nitrogen may be exerted in one or other of two definite directions. If this be granted, then there can be little doubt that the labile normal diazo-oxides possess the *Syn*-configuration, for in this series the coalescence of the contiguous associated radicles readily occurs with the elimination of nitrogen. The stable *iso*diazo-derivatives should by exclusion have the *Anti*-structure.[1]

There is one point, however, in which the analogy between oximes and diazo-oxides breaks down ; the stereo-isomeric oximes give rise to isomeric oxygen-ethers, whereas both the isomeric diazo-oxides yield the same *O*-ether. These *O*-ethers are explosive and combine with bases and phenols in the presence of alkali hydroxides or carbonates yielding azo-compounds. They are accordingly placed by Bamberger in the *Syn* or normal series.[2] Hantzsch, on the contrary, points out that in their capacity for forming azo-derivatives they do not differ markedly from the *iso*- or *anti*-diazo-derivatives. The exact relationship of these ethers to the metallic diazo-oxides can scarcely be considered as finally settled.

The *iso*- or *anti*-diazo-oxides undoubtedly exhibit the phenomenon of tautomerism, and, under certain conditions, react in accordance with the formula R.NH.NO, the formation of *N*-ethers, RN(alk).NO (secondary aromatic nitrosamines), being a case in point.

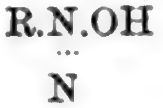
Structural Formulæ for the Isomeric Diazo-oxides.—The hypothesis that the isomeric diazo-oxides are structurally different has been defended by Bamberger [3] and Blomstrand,[4] who maintain that the normal diazo-oxide is a diazonium derivative, having the same configuration as the original diazonium salts. There is no longer any difference of opinion with respect to the oxime formula of the *iso*diazo-oxides, and accordingly the second hypothesis may be thus graphically illustrated



$$\begin{array}{l}R.N.Cl\\ \;\vdots\\ \;N\end{array} \rightarrow \begin{array}{l}R.N.OK\\ \;\vdots\\ \;N\end{array} \rightarrow R.N:NOK$$

diazonium chloride. normal diazo-oxide. *iso*-diazo-oxide.

One grave objection to the theory is at once detected from this diagram which indicates that the diazonium hydroxide



$$\begin{array}{l}R.N.OH\\ \;\vdots\\ \;N\end{array}$$

is capable of acting not only as an acid, but also as a strong base. The difficulties attending this assumption will be considered at greater length in the sequel.

Existence of Syn-diazo-Sulphonates, Cyanides, &c.—Hantzsch, who obtained a very unstable red potassium benzenediazo-sulphonate isomeric with Fischer's yellow diazo-sulphonate $C_6H_5.N_2.SO_3K$, asserted that these isomerides belonged to the *syn-* and *anti*-diazo-series respectively,[1] but Bamberger objected to this classification and showed that the red salt has the properties of a sulphite $C_6H_5N_2.O.SO_2K$.[2]

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[1] Hantzsch, *Ber.*, 1894, **27**, 1702 ; 1895, **28**, 676, 1734.

[2] *Ber.*, 1895, **28**, 225.

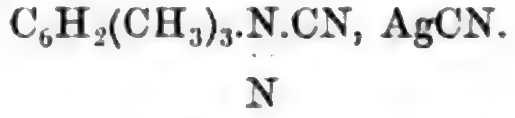
[3] *Ber.*, 1895, **28**, 444, 826, 1218.

[4] *Journ. prakt. Chem.*, 1896, **53**, 169 ; 1897, **54**, 305 ; 1897, **55**, 480.

The former investigator has, however, succeeded in isolating a series of isomeric diazo-cyanides.[3] *p*-Chlorobenzenediazonium chloride, when treated with cold potassium cyanide solution, yields a labile salt which readily evolves nitrogen, forms *p*-chlorobenzonitrile on treatment with copper powder, and passes into a stable isomeride. The latter, which is not affected by copper powder and may even be distilled in steam, is undoubtedly the *anti*-diazo-cyanide, whilst the labile derivative belongs to the *syn*-diazo-series. Both isomerides have a yellow colour, and this fact tends to exclude the view that the labile derivative is a diazonium cyanide, for the diazonium radicle gives colourless salts with colourless acids.

The *syn*-diazo-cyanides are more stable when the aromatic nucleus attached to the diazo-group contains substituent radicles.

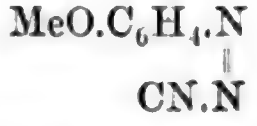
When a diazonium chloride is treated with a suspension of silver cyanide the colourless solution obtained, after filtering off the insoluble yellow *syn*-diazo-cyanide, contains a soluble double cyanide which is considered by Hantzsch and Danziger[4] to be a diazonium derivative. The double cyanide derived from ψ-cumenediazonium chloride has been isolated and its properties are best expressed by the formula



$$C_6H_2(CH_3)_3.\underset{\substack{\vdots\\ N}}{N}.CN,\ AgCN.$$

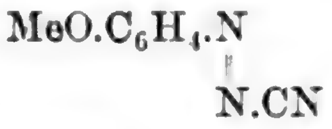
The *anti*-diazo-cyanide does not yield this double salt.

The formation of this double diazonium cyanide suggests that the sparingly soluble *syn*-diazo-cyanide may exist in solution in a state of equilibrium with the isomeric diazonium salt, and further confirmation of this hypothesis has recently been obtained[5] by a study of the cyanides obtained from *p*-methoxybenzenediazonium bromide and chloride. These salts by double decomposition with potassium cyanide in alcoholic solution yield the *syn*-diazo-cyanide



$$\begin{array}{r} MeO.C_6H_4.N\\ \|\\ CN.N \end{array}$$

an orange-red insoluble substance (melting-point 51°) which couples with β-naphthol, and slowly changes into the non-coupling *anti*-salt



$$\begin{array}{l} MeO.C_6H_4.N\\ \|\\ N.CN \end{array}$$

a brownish-red compound melting at 121°.

The existence of a third isomeric cyanide is indicated by evaporating at the ordinary temperature in the presence of excess of hydrogen cyanide an aqueous solution of *p*-methoxybenzenediazonium hydroxide. The colourless, crystalline substance obtained has the composition

$$MeOC_6H_4N_2CN,\ HCN,\ 2H_2O,$$

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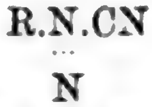
[1] *Ber.*, 18 , **27**, 1726.
[2] *Ber.*, 1894, **27**, 2930.
[3] *Ber.*, 1895, **28**, 666.
[4] *Ber.*, 18 **30** 2529.
[5] *Ber.*, 1900, **33**, 2161 ; 1901, **34**, 4166.

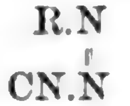
and possesses all the properties of a true metallic salt; it is very soluble, and its solution is an electrolyte. Moreover, the double salt condenses with β-naphthol and is converted into the yellow *syn*-diazo-cyanide by the action of alkaline solutions.

These results show that diazotised *p*-anisidine gives rise to the three cyanides demanded by the stereochemical hypothesis



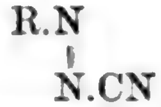
$$\begin{array}{c}R.N.CN\\ \vdots\\ N\end{array}$$

colourless soluble
electrolyte.



$$\begin{array}{c}R.N\\ \parallel\\ CN.N\end{array}$$

coloured labile
non-electrolyte.



$$\begin{array}{c}R.N\\ \parallel\\ N.CN\end{array}$$

coloured stable
non-electrolyte.

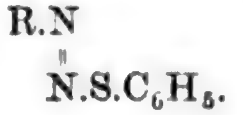
The opposite view only accounts for the existence of two isomeric cyanides, one having the constitution of a normal diazonium salt, and the other that of a diazo-cyanide of the *iso*diazo-series.

The *syn*- and *anti*-diazo-cyanides cannot be regarded as diazonium salts comparable with those of the mineral acids, for on the one hand they are non-electrolytes, dissolving only sparingly in water, and on the other they are distinctly coloured substances, readily soluble in the organic solvents.

Their colour confirms the assumption that they contain the group $N{=}N$, in common with azo-compounds. The criterion of colour must, however, be applied with caution, for the *syn*- and *anti*-alkali salts derived from diazotised sulphanilic acid are colourless.

Attempts made to obtain, in a state of purity, *syn*- and *anti*-diazo-derivatives containing other radicles in the place of cyanogen have not proved successful.

The diazonium salts or the alkali *anti*-diazo-oxides, when treated with the alkali phenylmercaptides, yield diazo-thioethers, which do not condense with β-naphthol, and are accordingly taken to belong to the anti-series,



$$\begin{array}{c}R.N\\ \parallel\\ N.S.C_6H_5.\end{array}$$

Only in the case of *p*-chlorobenzenediazothiophenyl ether was an explosive intermediate compound observed which may possibly be a *syn*-derivative. Phenol-*p*-diazo-hydroxide, $HOC_6H_4N_2OH$, and hydrogen sulphide yield a hydrosulphide, $HOC_6H_4.N_2.SH, H_2S$, which is possibly an *anti*-diazo-derivative.[1]

By treating *p*-nitrobenzenediazonium chloride with hydrogen sulphide, Bamberger[2] obtained three products:—(i) a hydrosulphide $NO_2C_6H_4N_2SH, H_2S$, or $NO_2C_6H_4N(SH).NH.SH$, which, like the preceding thio-derivatives, does not couple with phenol; (ii) a very explosive monosulphide $(NO_2C_6H_4N_2)_2S$, condensing with phenols and decomposing in benzene at the ordinary temperature to yield *p*-nitrodiphenyl, hydrogen sulphide, and nitrogen; (iii) a stable disulphide $(NO_2C_6H_4N_2)_2S_2$, which slowly couples with the phenols, and is decomposed by benzene or toluene. The monosulphide is probably a *syn*-diazo-derivative, whilst the disulphide is considered to be an *iso*-(*anti*)-diazo-compound.

Diazo-anhydrides.—The isomeric alkali diazo-oxides differ in their behaviour towards cold dilute acetic acid, the *anti*-diazo-oxides giving rise to hydroxides $R.N_2OH$, which are colourless unless they contain substituent nitro-groups, whilst the *syn*-isomerides furnish extremely explosive yellow diazo-anhydrides.[1] These substances, which may sometimes be obtained by treating a diazonium salt with an alkali *syn* diazo-oxide, slowly couple with the phenols, yield *O*-diazo ethers with the alcohols, and react explosively with benzene, yielding diphenyl-derivatives. According to Bamberger's earlier papers the anhydrides should have the formula

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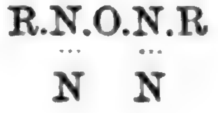
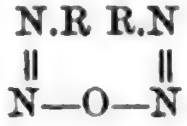
[1] *Ber.*, 1895, **28**, 3237.

[2] *Ber.*, 1896, **29**, 272.



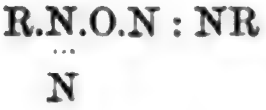
$$R.\underset{\underset{N}{\vdots}}{N}.O.\underset{\underset{N}{\vdots}}{N}.R$$

Hantzsch's stereo-chemical formula,[2]



$$\begin{array}{ccc} N.R & & R.N \\ \| & & \| \\ N & -O- & N \end{array}$$

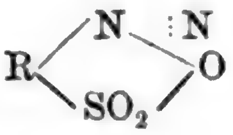
however, explains why the anhydrides readily yield *syn*-diazo-cyanides on treatment with hydrogen cyanide,[3] but only very slowly dissolve in hydrochloric acid to form diazonium chlorides. Bamberger has since suggested another formula for these substances, which assumes that they are salts of the basic diazonium hydroxide with the isomeric acidic diazohydroxide



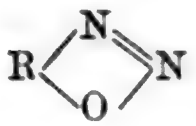
$$R.\underset{\underset{N}{\vdots}}{N}.O.N : NR$$

This configuration accounts for their formation from a diazonium chloride and an alkali diazo-oxide. The first of these formulæ is the least probable, but it is not possible at present to decide between the remaining two.

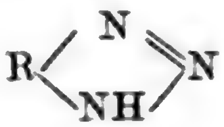
Cyclic Diazo-compounds.—Diazotised sulphanilic acid and other cyclic diazo-compounds are taken to be either diazonium salts,



or *syn*-diazo-anhydrides,[4]



the introduction of negative substituent radicles increasing the tendency to assume the *syn*-configuration. The azimino-derivatives are assumed to be *syn*-compounds,



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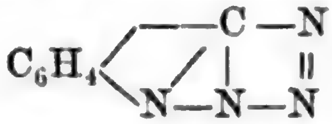
[1] Bamberger, *Ber.*, 1896, **29**, 446.

[2] *Ber.*, 1896, **29**, 1067.

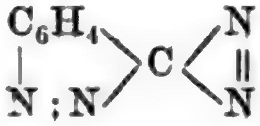
[3] *Ber.*, 1898, **31**, 636.

[4] Hantzsch, *Ber.*, 1895, **28**, 1734, and *Ber.*, 1896, **29**, 1522.

The triazolenes prepared by Bamberger[1] by the action of nitrous acid on amino-indazoles were assumed to have the formula,

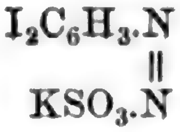


Hantzsch, however, advocates the constitution[2]



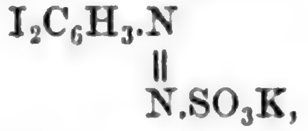
Diazo-sulphonates.—These substances, prepared by the action of potassium sulphite on the diazonium chlorides, appear generally to exist in two modifications, but in most cases the *syn*-isomeride is so unstable that it has not been isolated in a pure state. The fact that both modifications are distinctly coloured suggests that they have the constitution $R.N:N.SO_3K$, analogous to the azo-compounds; the *syn*-isomeride has invariably a more intense colour than the *anti*-salt.

Syn-2 : 4-di-iodobenzenediazo-sulphonate,



$$\begin{array}{c} I_2C_6H_3.N \\ \| \\ KSO_3.N \end{array}$$

is an orange substance, whilst the *anti*-salt,



$$\begin{array}{ll} I_2C_6H_3.N & \\ \quad\quad\quad\ \ \| & \\ \quad\quad\quad\ \ N.SO_3K, & \end{array}$$

is yellow.

The naphthylamines behave exceptionally, yielding only *syn*-diazosulphonates; these are not converted into the *anti*-salt on warming, but decompose, yielding the corresponding azo-naphthalenes.[3]

Diazo-phenylsulphones.[4]—By the action of benzenesulphinic acid on the diazo-cyanides, diazo-sulphones $RN_2.SO_2C_6H_5$ are produced; the action goes immediately with *syn*-diazo-cyanides, but only slowly with their *anti*-salts. The products do not exhibit stereo-isomerism, and probably belong to the *anti*-series; the *syn*-series has not been isolated.

C. *Diazoamines considered as Anti-diazo-compounds.*

Isodiazotisation of Aromatic Primary Amines.—The action of nitrous acid on the salt of an aromatic amine leads to the production of a diazonium salt, the basic nitrogen atom retaining its pentavalency throughout the operation. When the interaction occurs between nitrous acid and the free base, an *iso*-diazo-hydroxide is formed which condenses with a molecular proportion of primary amine, yielding a diazoamine. The direct isodiazotisation of the base may also be effected either by passing nitrous fumes into its solution in dry ether or ethyl acetate,[5] or by treating the amine with an alcoholic solution of amyl nitrite and sodium ethoxide;[6] in the former case a mixture of normal and

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[1] *Ber.*, 1899, **32**, 1773.

[2] *Ber.*, 1902, **35**, 888.

[3] Hantzsch and Schmidt, *Ber.*, 1897, **30**, 71.

[4] Hantzsch and Singer, *Ber.*, 1897, **30**, 312.

[5] *Ber.*, 1894, **27**, 1948.

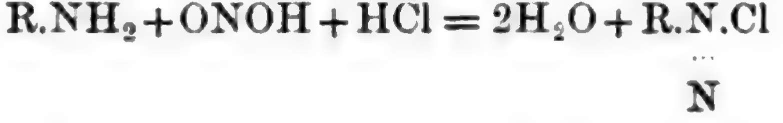
[6] *Ber.*, 1900, **33**, 3511.

iso-diazo-hydroxides results, whilst the latter experiment gives rise to the alkali *iso*diazo-oxide.

Migration of the Diazo-radicle.—Griess noticed that a solution of diazobenzenesulphonic acid and *p*-toluidine hydrochloride gave the reactions of a mixture containing *p*-toluenediazonium chloride and sulphanilic acid,[1] and more recently Schraube and Fritsch[2] showed that a similar rearrangement occurs in the case of a dilute solution of *p*-nitrobenzenediazonium chloride and *p*-toluidine. These investigators state that the direction of the change is constant either in acid or neutral solution; the velocity of migration, however, diminishes rapidly as the amount of acid is increased, and a large excess of this reagent altogether prevents the transformation. These results appear to show that the diazo-radicle passes from the less to the more positive radicle, but Hantzsch and F. M. Perkin found that a migration in the opposite sense occurs with benzenediazonium chloride and *p*-bromaniline.[3] It may therefore be supposed that generally, when neutral or slightly acid solutions of a diazonium salt and a primary aromatic amine are mixed, there will be a certain amount of rearrangement due to the migration of the diazo-group.

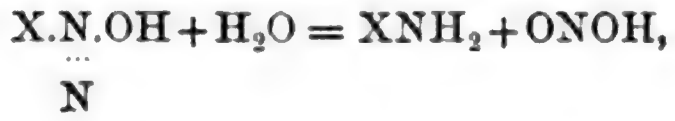
This migration of the diazo-radicle is probably associated with the changes which occur when this group passes from the diazonium to the diazo configuration. Bamberger[4] found that, in the inverse change, a transitory elimination of nitrous acid occurred,

$$R.N:NOH + H_2O = R.NH_2 + ONOH$$



$$R.NH_2 + ONOH + HCl = 2H_2O + R.\underset{\underset{N}{\vdots}}{N}.Cl$$

this reaction being effected by dissolving an alkali *iso*-diazo-oxide in cold mineral acid. If the transitory elimination of nitrous acid is assumed to occur in the change from the diazonium to the diazo condition, then an explanation of the migration of the diazo-radicle is obtained, which also accounts for the fact that the same mixed diazoamine is produced from the couple XN_2Cl and YNH_2 as from the combination of YN_2Cl and XNH_2. In the former case the diazonium hydroxide, liberated from its salt by the addition of sodium acetate, would undergo hydrolysis,



$$X.\underset{\underset{N}{\vdots}}{N}.OH + H_2O = XNH_2 + ONOH,$$

and the nascent nitrous acid would at once isodiazotise a portion of each of the primary amines XNH_2 and YNH_2, giving rise to the diazo-hydroxides $X.N:NOH$ and $YN:NOH$. The latter substances and the unaltered primary bases would then condense, and a mixed diazoamine would be produced, this substance consisting of a solid solution of $XN_2.NHY$ in $YN_2.NHX$, the proportion of the two constituents depending on the nature of the two aromatic radicles X and Y. In certain cases the product may consist largely of the symmetrical diazoamines $XN_2.NHX$ and $YN_2.NHY$, but the formation of these compounds is equally well explained by the hypothesis based on the transitory elimination of nitrous acid. The formation of the mixed diazoamine occurs even when X and Y are radicles derived from different hydrocarbons, and substances of this type containing naphthalene and tetrahydronaphthalene nuclei have been isolated.[1]

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[1] *Ber.*, 1882, **15**, 2190.

[2] *Ber.*, 1896, **29**, 287.

[3] *Ber.*, 1897, **30**, 1412.

[4] *Ber.*, 1895, **28**, 326.

The migration of the diazo-group is prevented by the alkylation of the primary aromatic amine, and the couples XN_2Cl, YNHR and YN_2Cl, XNHR give rise to two isomeric mixed alkyl diazo-amines, XN_2NRY and YN_2NRX.[2]

The comparative stability of the diazoamines and their production from *iso*diazo-oxides point to their having the *anti*-diazo configuration; the *syn*-isomerides have not been produced, although Hantzsch and F. M. Perkin (*loc. cit.*) obtained abnormal diazoamines which form an exception to the rule governing the formation of mixed diazoamines. The compound $ClC_6H_4N_3HC_6H_5$, for example, exists in two modifications, which give rise to the same products on fission with hydrochloric acid or phenylcarbimide. The suggestion that these two isomerides should be represented by the formulæ $C_6H_5N:N.NH.C_6H_4Cl$ and $C_6H_5.NH.N:NC_6H_4Cl$, is not justified by the result of their fission.

D. *The Diazonium Radicle compared with Quaternary Ammonium Ions.*

The change of opinion in favour of the Strecker-Blomstrand formula for the diazonium salts was in the first place based on certain general analogies existing between the salts of nitrogenous bases.

The older view of the constitution of diazonium salts indicates that these substances form an exception to the rule that basic nitrogen is pentavalent in its salts, and yet the compounds in question behave as the salts of bases more powerful than the aromatic amines from which they are derived. The diazonium bases are capable of combining with the weaker acids, and yield soluble alkaline carbonates, *e.g.* $(C_6H_5N_2)_2CO_3$, and unstable nitrites and acetates. Moreover, this view involves the assumption that the compound $C_6H_5N:NOH$ can react as a strong ammonium base towards acids and as a distinctly acidic substance towards the alkali hydroxides. Hantzsch showed that the diazonium salts of the mineral acids are strongly ionised in dilute solution, but do not exhibit any trace of hydrolytic dissociation; the ionisation is, however, considerably diminished by the introduction of negative radicles into the aromatic nucleus of the diazonium compound.[3]

Determinations of the electrical conductivity of solutions of benzenediazonium chloride and nitrate showed that the benzenediazonium radicle is strictly comparable with other quaternary ammonium ions. The rate of migration of the benzenediazonium ion at 25° is 45·7, the corresponding constants for the methylpyridinium, $C_5H_5NCH_3$, and tetramethylammonium ions, $N(CH_3)_4$, being 44·3 and 43·6 respectively.

The molecular conductivity of the solutions of diazonium salts increases with the dilution, just as in the case of the corresponding potassium and ammonium compounds.

A physico-chemical study of the solutions of benzenediazonium hydroxide showed that the affinity constant of this base at 0° is seventy times greater than that of ammonium hydroxide, and somewhat exceeds that of piperidine. The affinity constants of methoxybenzenediazonium hydroxide and ψ-cumidinediazonium hydroxide are even greater, and approximate closely to those of the alkali hydroxides. The effect of introducing halogen radicles into the aromatic nucleus is indicated in a striking manner in the following table:—

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[1] Morgan, *Trans.*, 1902, **81**, 91; and C. Smith, *ibid.* 901.

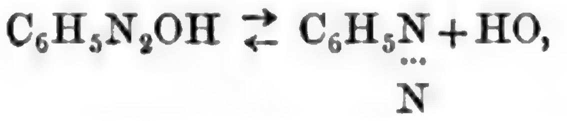
[2] Meldola and Streatfeild, *Trans.*, 1887, **51**, 818; 1889, **55**, 610, 1105; 1890, **57**, 785.

[3] *Ber.*, 1895, **28**, 1734.

	k = velocity constant
$C_6H_5N_2OH$	0·123
$BrC_6H_4N_2OH$	0·0149
$2:4Br_2C_6H_3N_2OH$	0·0136
$2:4:6Br_3C_6H_2N_2OH$	0·0014

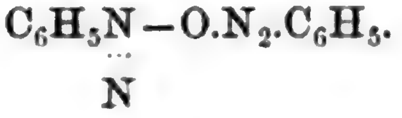
A comparison of the electrical conductivity experiments with the results obtained in the hydrolysis of ethyl acetate by benzenediazonium hydroxide shows that, in 1/128 N solutions at 0°, approximately 33 per cent. of the base exists in the ionised condition.

The ionisation detected in the hydrolysis experiment is greater than that indicated by the conductivity determinations, and this shows that the electrolytic dissociation is exclusively due to the reaction



$$C_6H_5N_2OH \rightleftarrows \underset{\underset{N}{\vdots}}{C_6H_5N} + HO,$$

and not to the electrolysis of a diazonium *syn*-diazo-oxide,

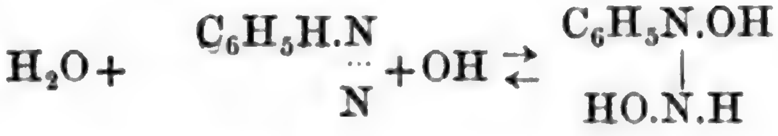


$$\underset{\underset{N}{\vdots}}{C_6H_5N} - O.N_2.C_6H_5.$$

Condition of the Non-ionised Diazonium Hydroxide.—The solution of benzenediazonium hydroxide differs essentially from one containing piperidine in its behaviour towards alkali hydroxides, generating with these reagents an appreciable amount of heat exactly like a weak acid. This reaction is also indicated by determinations of the electrical conductivities of solutions of the diazonium hydroxide when treated with one, two, or more molecular proportions of sodium hydroxide.

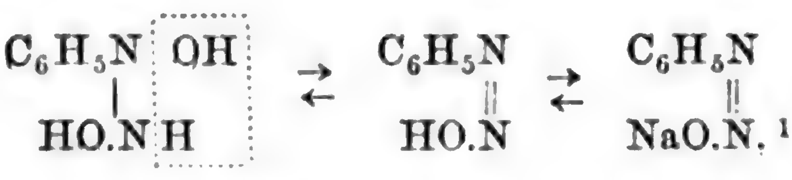
The simplest explanation of this phenomenon is based on the assumption that the non-ionised portion of the diazonium hydroxide exists in solution in a hydrated form which, on the addition of alkali hydroxide, yields the alkali salt, the acidic *syn*-diazo-hydroxide behaving in this respect precisely like the similarly constituted oximes.

Before the addition of alkali the equilibrium may be thus represented:—



$$H_2O + \underset{\underset{N}{\vdots}}{C_6H_5H.N} + OH \rightleftarrows \begin{array}{c} C_6H_5N.OH \\ | \\ HO.N.H \end{array}$$

The addition of the alkali hydroxide causes the hydrate to lose water forming the *syn*-diazo-hydroxide, which then gives rise to a certain amount of sodium derivative,



$$\begin{array}{c} C_6H_5N \;\; OH \\ | \\ HO.N \;\; H \end{array} \rightleftarrows \begin{array}{c} C_6H_5N \\ \| \\ HO.N \end{array} \rightleftarrows \begin{array}{c} C_6H_5N \\ \| \\ NaO.N. \end{array}[1]$$

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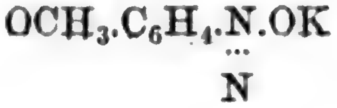
[1] Hantzsch and Davidson, *Ber.*, 1898, 31, 1612.

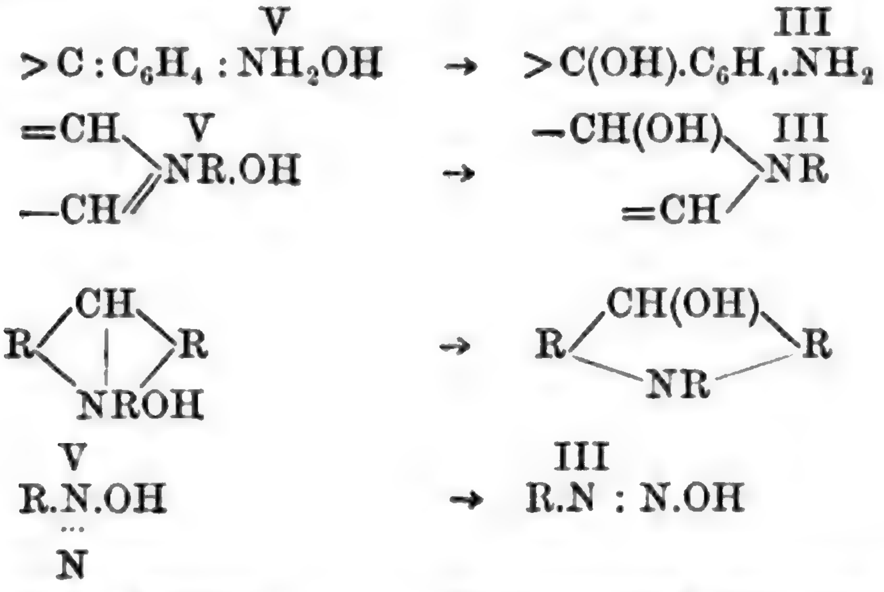
If this hypothesis is not accepted, then it must be assumed that a quaternary ammonium hydroxide, having the functions of a strong base, is also capable of behaving as an acid and yielding an alkali salt. The diazonium hydroxide derived from anisidine, for example, is a base comparable in strength with the alkalies, and yet it gives rise to a stable potassium derivative,[1] which, according to the alternative theory, has the formula



$$\mathrm{OCH_3.C_6H_4.}\underset{\underset{\mathrm{N}}{\vdots}}{\mathrm{N}}\mathrm{.OK}$$

There are, however, absolutely no other examples of strong alkalies behaving in this way.

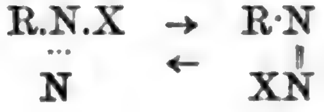
On the other hand, the hypothesis based on the change of configuration due to the labile nature of the diazonium hydroxides, brings these bases into line with other quaternary ammonium derivatives. It is well known that almost all the quaternary ammonium hydroxides, excepting those in which the nitrogen is attached to four fully saturated hydrocarbon radicles, are unstable, and pass into substances in which the hydroxyl group is no longer attached to the aminic nitrogen. This alteration is noticed in the bases of the rosaniline, pyridine, and acridine series; the transformations taking place in each case being indicated by the following diagrams:—



Ammonium derivatives. *Pseudo-ammonium derivatives.*

According to this generalisation the *syn*-diazo-hydroxides are to be regarded as pseudo-diazonium derivatives.[2]

Solid Diazonium Halides.—The unstable character of certain diazonium halides seems to be connected in some way with their colour, the most highly coloured salts being very explosive. These coloured salts are found to give colourless solutions, in which the salt is undoubtedly in the form of a diazonium compound. The appearance of colour in the solid state is considered to be due to the formation of a certain amount of *syn*-diazo-derivative, in accordance with the condition of equilibrium:—



$$\underset{\underset{\mathrm{N}}{\vdots}}{\mathrm{R.N.X}} \rightleftarrows \underset{\underset{\mathrm{XN}}{\|}}{\mathrm{R{\cdot}N}}$$

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[1] *Ber.*, 1900 **33**, 2158.

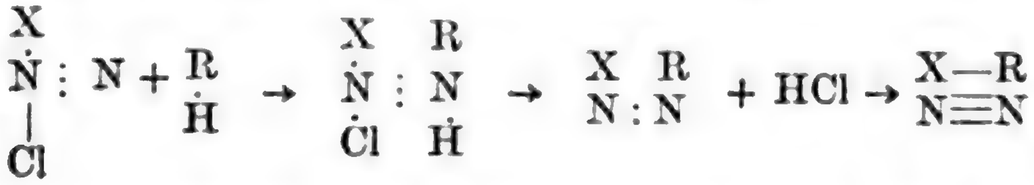
Ber., 1899, **32**, 3109; 1900, **33**, 278.

The amount of coloured *syn*-compound present depends largely on the nature of the acid radicle X.

The diazonium chlorides, and nearly all the bromides, are colourless and comparatively stable. The iodides are all coloured, and very explosive, the thiocyanates are somewhat less coloured than the iodides, and are intermediate in stability between these and the bromides.

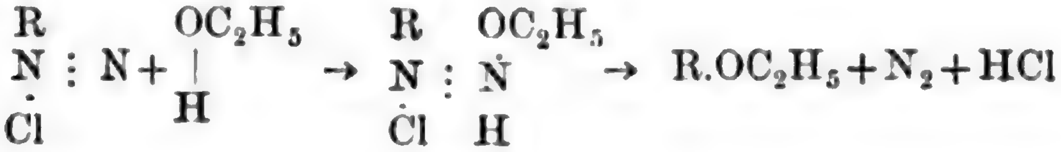
The influence of substituent radicles in the aromatic radicle R is scarcely noticeable with the diazonium chlorides; but with the other salts it is found that the stability is increased by the introduction of methyl and methoxy groups, and diminished by that of acidic radicles.[1] At low temperatures even the very explosive diazonium salts become stable, and it is noticed that, on cooling, their colour is perceptibly diminished.[2]

The Residual Affinity of Diazonium Salts.[3]—The characteristic fission of diazonium salts is very probably due to the preliminary addition of a reagent HR, and the subsequent elimination of the hydride of the acid radicle with the formation of an unstable *syn*-diazo-compound,

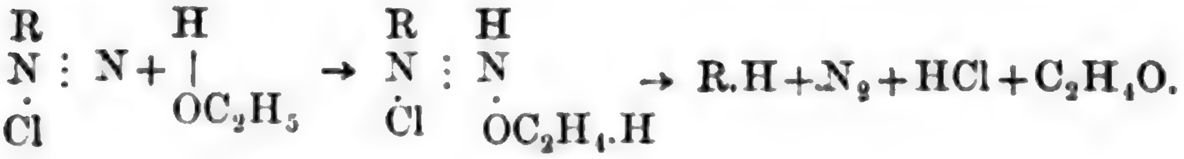


$$\begin{matrix}X\\ \dot{N}\\ |\\ Cl\end{matrix} : N + \begin{matrix}R\\ \dot{H}\end{matrix} \rightarrow \begin{matrix}X & & R\\ \dot{N} & : & N\\ \dot{Cl} & & \dot{H}\end{matrix} \rightarrow \begin{matrix}X & & R\\ N & : & N\end{matrix} + HCl \rightarrow \begin{matrix}X-R\\ N\equiv N\end{matrix}$$

This hypothesis affords a general explanation of the Sandmeyer reaction, and also of the interaction between diazonium salts and water or alcohol.[4]



$$\begin{matrix}R\\ N\\ \dot{Cl}\end{matrix} : N + \begin{matrix}OC_2H_5\\ |\\ H\end{matrix} \rightarrow \begin{matrix}R & & OC_2H_5\\ N & : & \dot{N}\\ \dot{Cl} & & H\end{matrix} \rightarrow R.OC_2H_5+N_2+HCl$$



$$\begin{matrix}R\\ N\\ \dot{Cl}\end{matrix} : N + \begin{matrix}H\\ |\\ OC_2H_5\end{matrix} \rightarrow \begin{matrix}R & & H\\ N & : & N\\ \dot{Cl} & & \dot{O}C_2H_4.H\end{matrix} \rightarrow R.H+N_2+HCl+C_2H_4O.$$

The cuprous salts of the Sandmeyer reaction combine with *syn*-diazo-compounds to form coloured double salts of the azo-type, and, in this way, induce the conversion of the diazonium salt into the pseudo-diazonium or *syn*-form which subsequently decomposes in the characteristic manner.

The diazonium perhalides are substances analogous with the periodides of potassium, cæsium, and the quaternary ammonium bases. The halogen atoms are certainly not attached to both nitrogen atoms, since the compound $C_6H_5N_2ClBrI$ is produced either from $C_6H_5N_2Cl$ and IBr or from $C_6H_5N_2Br+ICl$.[5]

Hydrolytic Dissociation of the Alkali Diazo-oxides.—It has already been seen that the metallic *syn*- and *anti*-diazo-oxides are much alike in their general chemical behaviour, providing that their reactions are studied in fairly alkaline solutions. The *syn*-isomerides, however, exhibit anomalous properties in dilute neutral solution, and this phenomenon has been found, by determinations of the electrical conductivity,[6] to be due to the abnormally large hydrolytic dissociation of these substances. This is explained by the hypothesis already employed in considering the condition of the dissolved diazonium hydroxide. The *syn*-diazo-oxide exhibits a higher degree of hydrolytic dissociation than potassium cyanide or other dissociating salts, because the acid set free by hydrolysis is not stable, but passes into the intermediate hydrate and thence to the diazonium hydroxide :—

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[1] *Ber.*, 1900, **33**, 2179.

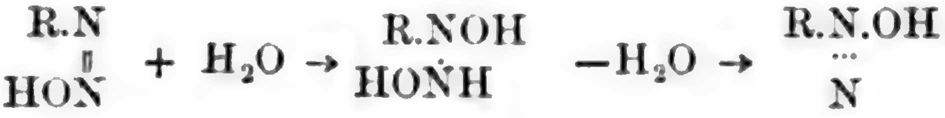
[2] *Ber.*, 1901, 34, 4166.

[3] *Ber.*, 1897, **30**, 2548; 1898, **31**, 2053.

[4] *Ber.*, 1900, **33**, 2517.

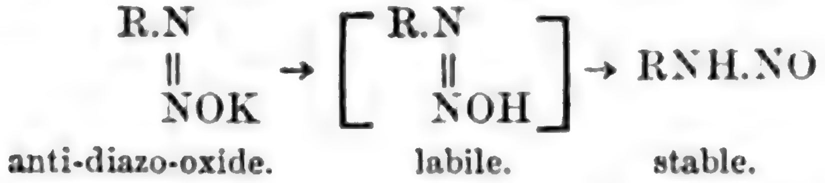
[5] *Ber.*, 1895, **28**, 2754.

[6] *Ber.*, 1898, **31**, 1612.



$$\begin{matrix}\text{R.N}\\ \| \\ \text{HON}\end{matrix} + H_2O \rightarrow \begin{matrix}\text{R.NOH}\\ \text{HONH}\end{matrix} - H_2O \rightarrow \begin{matrix}\text{R.N.OH}\\ \vdots \\ \text{N}\end{matrix}$$

Anti-diazo-oxides and Primary Nitrosamines.—The alkali diazo-oxides behave like the salts of a distinctly acid substance, and are not greatly hydrolysed in dilute solution. When the dissolved salt is treated with the equivalent amount of hydrochloric acid, the electrical conductivity of the resulting solution shows that the only electrolyte present is the alkali chloride produced by the reaction. The solution obtained is perfectly neutral, and, conversely, when the substance, which is set free by the acid, is treated with the equivalent quantity of alkali the product is neutral. These phenomena indicate that the substance set free from the *anti*-diazo-oxide belongs to the class of pseudo-acids,[1] and accordingly the product is best represented as being a primary nitrosamine,

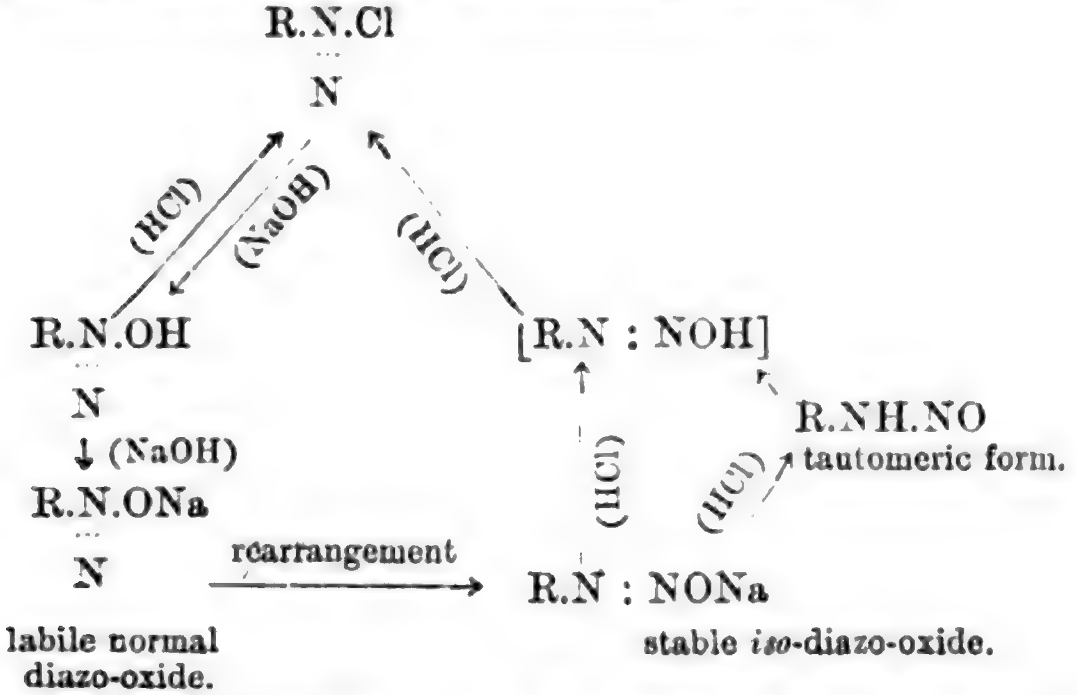


$$\begin{matrix}\text{R.N}\\ \| \\ \text{NOK}\end{matrix} \rightarrow \left[\begin{matrix}\text{R.N}\\ \| \\ \text{NOH}\end{matrix}\right] \rightarrow \text{RNH.NO}$$

anti-diazo-oxide. labile. stable.

The nitrosamines $Br.C_6H_4NH.NO$ and $NO_2.C_6H_4NH.NO$ have the characters of pseudo-acids; they do not react with phosphorus pentachloride, acetyl chloride, or ammonia in indifferent solvents, and dissolve only gradually in acids regenerating the diazonium salts.

Summary.—The theory of diazo-compounds, which ignores stereochemical differences and assumes that the diazo-oxides are structurally dissimilar, may be summarised in the following diagram :—



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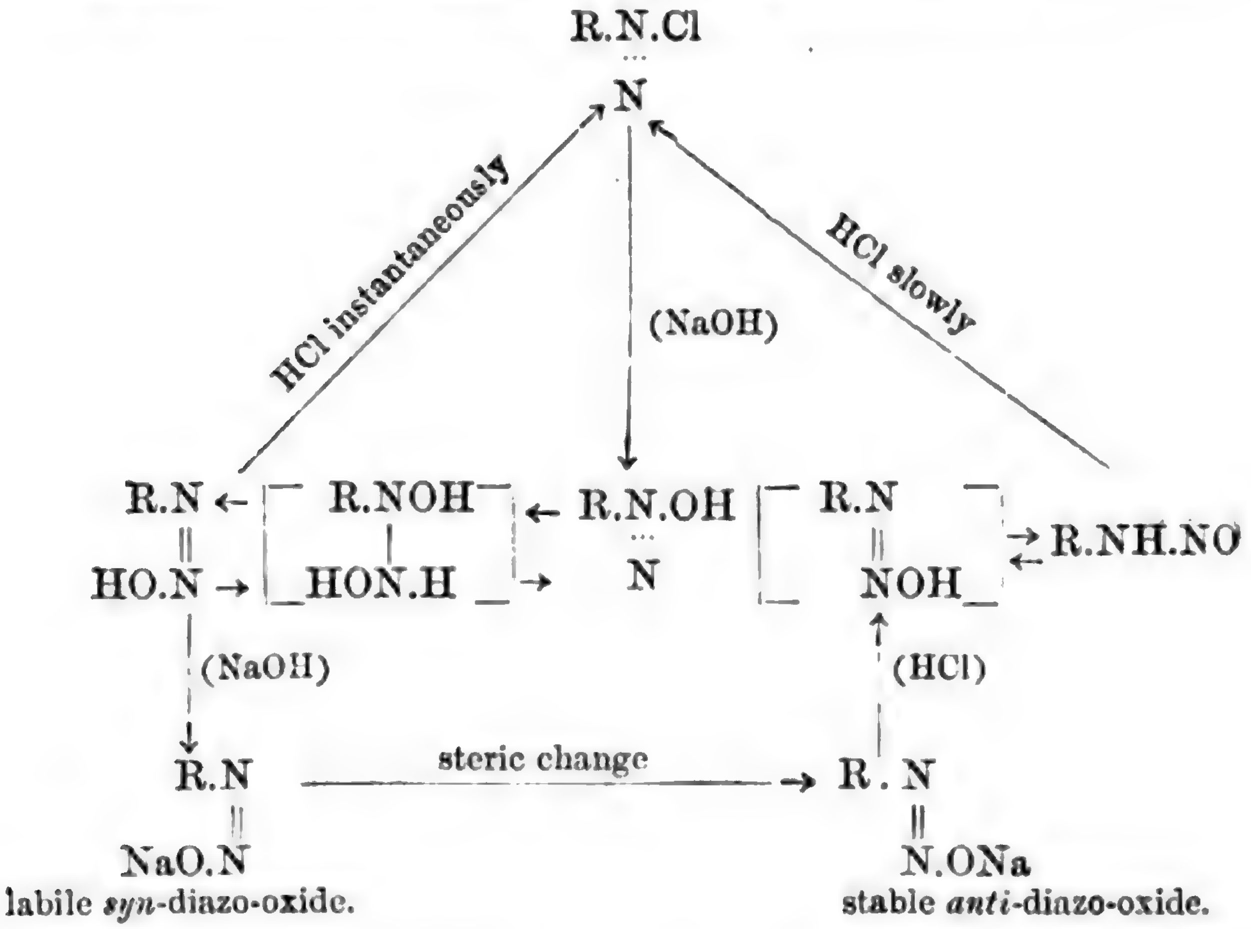
[1] *Ber.*, 1899, 32, 575, 1708.

The stereochemical theory may be briefly outlined as follows :—



The substances indicated in square brackets are hypothetical intermediate compounds, the existence of which is assumed in order to explain the tautomeric changes.

In our present state of knowledge a choice still remains between a theory of diazo-compounds which, although not assuming any spatial relationships, nevertheless offers an explanation of the isomerism of these substances which is applicable to this series of nitrogen-derivatives alone, and a stereochemical hypothesis which correlates the diazo-derivatives with other nitrogen compounds of a similar type and affords a general interpretation of a considerable group of experimental facts.

The assumption of *syn*- and *anti*-isomerism explains the production of the two series of coloured cyanides and sulphonates from the colourless diazonium salts. Moreover, the stereochemical hypothesis renders it possible to connect the relationship between the diazonium and *syn*-diazohydroxides with the general theory of quaternary ammonium compounds. In a similar manner the behaviour of the primary aromatic nitrosamines and the *anti*-diazo-oxides may be correlated with the general theory of pseudo-acids and their salts.

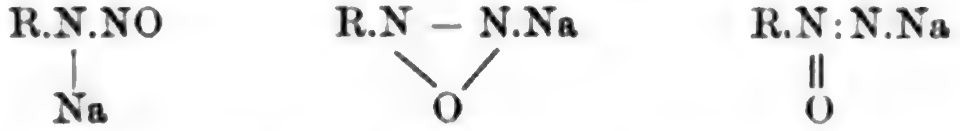
It may be urged against the stereo-chemical theory of diazo-compounds that the *syn*-diazo series is still very defective, being confined to three classes of substances, the metallic diazo-oxides, the diazo-cyanides, and diazo-sulphonates, and it is still possible that the isomeric cyanides and sulphonates may be shown to be structurally different. On the other hand the view that the *syn*-diazo-compounds have a diazonium configuration leads to conclusions which are not in accordance with experimental facts. This is particularly the case with the metallic diazo-oxides, for it becomes necessary to assume that the strongly basic diazonium hydroxides also react as acids. This hypothesis is in the highest degree improbable, there being no other example of a quaternary ammonium hydroxide possessing this dual nature.

Addendum.

I. *Additional Notes on the Stereochemical Theory.*—Since writing the foregoing report the author has received a communication from Professor Hantzsch containing the latest developments of the stereochemistry of the diazo-compounds.

The alternative views are fully discussed and the plane formulæ suggested for the *syn*-diazo derivatives, on the assumption that these substances differ structurally from their *anti*-isomerides, are shown to be incapable of accounting for the observed facts.

In addition to the diazonium formula, three other structural formulæ have been advanced for the metallic *syn*-diazo-oxides :

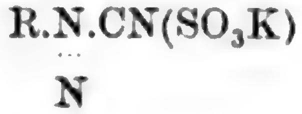


$$\begin{array}{ccc} \mathrm{R.N.NO} & \mathrm{R.N-N.Na} & \mathrm{R.N:N.Na} \\ | & \diagdown\quad\diagup & \| \\ \mathrm{Na} & \mathrm{O} & \mathrm{O} \end{array}$$

These configurations fail, in the following important points, to account for the behaviour of these metallic diazo-derivatives :

1. They do not furnish a simple explanation of the reciprocal transformation of these substances into diazonium salts and *vice versâ*.
2. They do not indicate that capacity for coupling with phenols to form azo-compounds, which is so essentially characteristic of the *syn*-diazo series.
3. Moreover, they involve the additional assumption that the isomerism of the metallic diazo-oxides differs essentially from that of the diazo-cyanides and diazo-sulphonates, inasmuch as the latter compounds cannot be formulated on these lines. This hypothesis is, however, unjustifiable for the *syn*-diazo derivatives of the three series (oxides, cyanides, and sulphonates) have comparable properties.

The only other structurally dissimilar formulæ available for the *syn*-diazo-cyanides and diazo-sulphonates are the diazonium formula



$$\begin{array}{c} \mathrm{R.N.CN(SO_3K)} \\ \vdots \\ \mathrm{N} \end{array}$$

and the configuration R.N N.CN(SO$_3$K).

The former of these is not in accordance with the general properties (colour and sparing solubility) of these derivatives, and moreover the electrolytic dissociation of the diazo-sulphonates into two ions confirms the view that the compounds are diazo-sulphonates, R.N:N.SO$_3$K, and not diazonium sulphites.

The second formula involves an entirely new assumption—namely, that of isomerism due to change of valency ; but even if this possibility be granted, the corresponding formulation does not furnish an explanation of the close relationship existing between the *syn* and *anti* series, for the isomeric pairs of diazo-compounds,

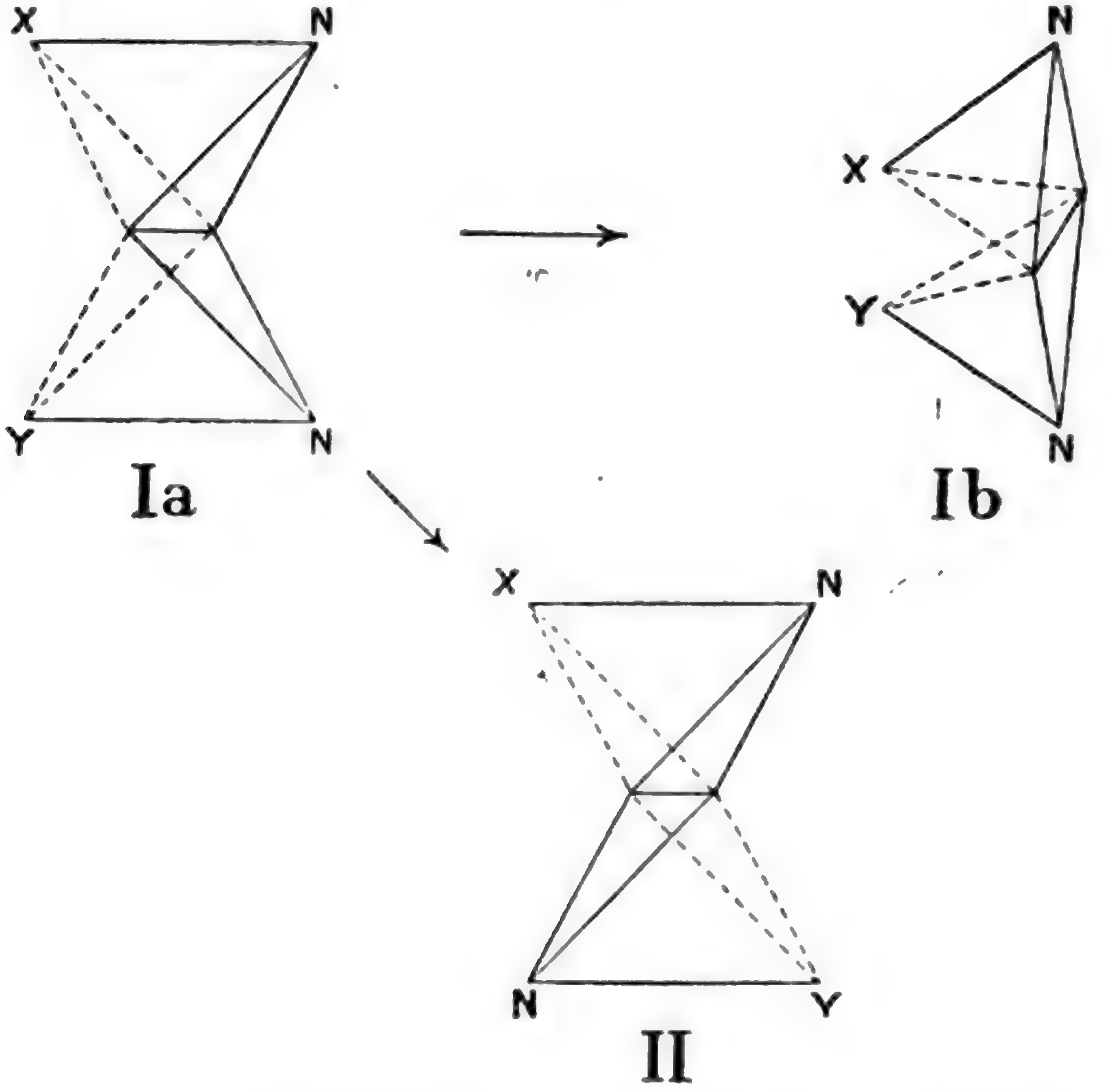
RN N.CN(SO$_3$K) and RN:N.CN(SO$_3$K),

being derivatives of pentavalent and trivalent nitrogen respectively, ought to differ completely in their chemical reactions.

In developing the stereochemical theory of the diazo-derivatives, Hantzsch adopts the space formulæ employed in explaining the isomerism of the oximes.

The assumption involved is that the valencies of the trivalent nitrogen atom are directed along the convergent edges of a regular tetrahedron, the atom itself being situated at the apex of the solid angle thus produced.

When two nitrogen atoms become doubly linked in a molecule, the compound which results is capable of existing in two stereomeric forms corresponding with the diagrams I*a* and II.

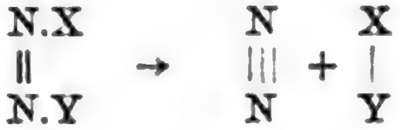


By means of these diagrams the *syn*- and *anti*-diazo derivatives may be compared with the stereomeric oximes and the *cis*- and *trans*-isomerides of doubly-linked carbon compounds.

The great instability of the *syn*-diazo series may be explained in terms of v. Baeyer's 'tension' theory. According to this hypothesis, the valencies linking together two conjugated atoms tend to set themselves in the same straight line, and when this is not possible, a stress is produced in the molecule which renders it unstable and prone to undergo rearrangement.

The diagram I*a* indicates a molecule in this unstable condition, the linking valencies of the two nitrogen atoms being inclined at an angle to each other. This intramolecular strain can be relieved by placing the sides of the tetrahedra bounded by continuous lines in the same plane, the necessary change in the spatial relationship of these figures being produced either by rearrangement (I*a* to II), or more simply by rotating the tetrahedra about their common edge (I*a* to I*b*).

The former operation represents the transformation of the labile *syn*-derivative into its stable *anti*-isomeride; the latter indicates the final condition of the *syn*-compound itself, and furnishes an explanation of the typical diazo-fission,

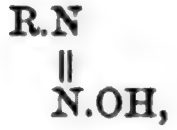


$$\begin{array}{c} N.X \\ \| \\ N.Y \end{array} \rightarrow \begin{array}{c} N \\ ||| \\ N \end{array} + \begin{array}{c} X \\ | \\ Y \end{array}$$

brought about by the close proximity of the radicles attached to the diazo-complex.

II. *Isolation of the Anti-diazohydroxides R.N:N.OH.*—Hantzsch has recently discovered that in certain cases both forms of the *anti*-diazohydroxides are capable of separate existence. The nitrosamine forms have already been studied; they are comparatively stable yellow compounds belonging to the category of pseudo-acids, and yield negative results when treated with phosphorus pentachloride, acetyl-chloride, phenyl-carbimide, or a dry ethereal solution of ammonia.

The newly isolated oxime forms



$$\begin{array}{c} R.N \\ \| \\ N.OH, \end{array}$$

corresponding with the metallic *anti*-derivatives R.N:NONa(K), are labile, colourless substances; they are true acids reacting with the agents enumerated in the preceding sentence.

The *syn*-diazohydroxides are only known in solution.

III. *Transformation of Diazonium Salts.*—The following observations should be added to the summary of miscellaneous substitutions:—

Meldola and Eyre have shown that in the dinitro-anisidines a nitro-group situated in the ortho- or para- position with respect to amidogen is replaced either by chlorine, when the base is diazotised in the presence of hydrochloric acid,[1] $OMe.C_6H_2(NO_2)_2N_2Cl \rightarrow OMe.C_6H_2Cl(NO_2)N_2.NO_2$, or by hydroxyl, when the operation is carried out in sulphuric acid.

The author has quite recently noticed a similar transformation in the case of 1-nitro-β-naphthylamine when diazotised in the presence of hydrochloric acid, $NO_2.C_{10}H_6N_2Cl \rightarrow Cl.C_{10}H_6.N_2.NO_2$, and further rearrangements of this nature have been observed by other investigators.[2]

Although under these conditions bromine may be replaced by chlorine, it does not appear possible to remove fluorine or iodine from the aromatic nucleus through the agency of the diazo-reaction (Hantzsch).

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[1] Meldola and Eyre, *Trans.*, 1901, **79**, 1077; 1902, **81**, 988.

[2] Gaess and Ammelburg, *Ber.*, 1894, **27**, 2211; Meldola and Streatfeild, *Trans.*, 1895, **67**, 909; Fr. Pat. 315932, Feb. 28, 1902.

Registration of Type Specimens of British Fossils.—Report of the Committee, consisting of Dr. H. WOODWARD (*Chairman*), Dr. A. SMITH WOODWARD (*Secretary*), Rev. G. F. WHIDBORNE, Mr. R. KIDSTON, Professor H. G. SEELEY, Mr. H. WOODS, *and* Rev. J. F. BLAKE.

DURING the past year an important list of the type specimens of fossils in the Norwich Museum has been published by Mr. Frank Leney, assistant curator. It was first issued in the 'Geological Magazine' for April and May 1902, and subsequently reprinted as a pamphlet with a preface by Dr. Henry Woodward.

Life-zones in the British Carboniferous Rocks.—Report of the Committee, consisting of Mr. J. E. MARR (*Chairman*), Dr. WHEELTON HIND (*Secretary*), Mr. F. A. BATHER, Mr. G. C. CRICK, Dr. A. H. FOORD, Mr. H. FOX, Professor E. J. GARWOOD, Dr. G. J. HINDE, Professor P. F. KENDALL, Mr. R. KIDSTON, Mr. G. W. LAMPLUGH, Professor G. A. LEBOUR, Mr. B. N. PEACH, Mr. A. STRAHAN, *and* Dr. H. WOODWARD. (*Drawn up by the Secretary.*)

COLLECTING has been carried on during the last year by Mr. D. Tait, of the Geological Survey, who kindly devoted his holiday to that purpose, and by Mr. J. T. Stobbs, F.G.S., lecturer on mining under the Staffordshire County Council. The Committee are to be congratulated on being able to obtain the help of such trained and skilled collectors.

Mr. Tait collected from the Black Limestones and shales resting on the white shelly Limestone at Poolvash, Isle of Man, where he rediscovered the plant-beds mentioned by Cumming in his work on the Isle of Man. He then worked in the beds of the same horizon in the Valley of the Hodder, near Stoneyhurst, and also in the neighbourhood of Flasby, Yorkshire.

Mr. Stobbs has confined his attention to the dark shales and Limestones resting on the white shelly Limestone in the Valley of the Noe, and at Mam Tor, near Castleton.

Most of the Cephalopoda have been submitted to Dr. A. H. Foord, and the plants have been sent to Mr. Kidston.

I have also collected and examined collections from certain horizons in Weardale, Redesdale, and Edendale, and while on an excursion with the Geologists' Association examined the beds and fauna of the Bishopton beds which succeed the Limestone Massif of Gower, lists of which I include in my report. I am indebted to my friend Dr. Wellburn for notes on the fish fauna of the Pendleside series.

I have recently had the privilege of examining, at the invitation of M. Dupont, of the Musée d'Histoire Naturelle of Brussels, a large collection of rock specimens and fossils which were obtained by Mr. Purvis when mapping the district round Clavier, a little north-east of Dinant. Some few outliers of yellowish and dark shales, black Limestones, cherts, and quartzites are found near Clavier (Explication de la Feuille de Clavier, Service de la Carte géologique du Royaume, 1883), which appear to me identical in character with rocks found in the Pendleside series. The shales and Limestones contain a typical and almost complete Pendleside fauna. I was able to identify the following species :—

Aviculopecten prætenuis.
Posidoniella lævis.
? Posidonomya membranacea.
Pteronites angustatus.
Chænocardiola Footii.
Orthoceras Morrisianum.
Orthoceras striato-annulosum.
Stroboceras bisulcatum.
Glyphioceras bilingue.
„ *diadema.*
Glyphioceras spirale.
Prolecanites compressus.
Athyris ambigua.
Chonetes Laguessiana.
Productus scabriculus.
„ *semireticulatus.*
Phillipsia Van der Grachtii, ? long-cheek spine.
Listracanthus Beyrichii.

At Visé, in beds of the same age, lying on the Shelly Limestone Massif are shales with—

Pterinopecten papyraceus
Posidonomya Becheri
Posidoniella lævis
Glyphioceras diadema

a fauna characteristic of the lower part of the Pendleside series, while the Chokier beds contain a fauna and have a lithological character indicating higher beds in the Pendleside series, such as are found in the bullions of Horsebridge Clough and Crimsworth Dean, Pule Hill, River Dane, and various other localities.

It is interesting to find this fauna present in its proper position in Western Europe, and the same fauna obtains in the Lower Carboniferous beds of Magdeburg still farther east,[1] and still farther east in the Culm of Herborn.[2]

The results of Mr. Tait's collecting are as follows :

Poolvash, Isle of Man :—

Black shale interbedded with lenticles and hummocks of limestone containing marine fossils, between tide-marks west of the barn at Poolvash Farm.

(There has been a great deal of lateral thrusting on the shore. These plant-beds should, I believe, rest on the shelly limestone.)

* With reference to these fossils, Mr. Kidston says they seem to be the same class of organism as the unknown Pendle Hill (Hook Cliff) fossil (found last year by Mr. Tait), but apparently specifically distinct. I would say they belong to Göpperts' and Hall's *Dictyonema.*

PLANTS.

Adiantites Machaneki, Stur.
Adiantites antiquus, Ett. sp.
Sphenopteris pachyrachis, Göpp.
„ var. *stenophylla*, Göpp.
Sphenopteris allied to sp. *bifida*, L. & H., or sp. *subgeniculata*, Stur.

* *? Dictyonema*, 2 sp.

MOLLUSCA.

Posidonomya Becheri.
Pterinopecten (*Aviculopecten*) *papyraceus.*
Solenomya costellatus.
Orthoceras Morrisianum.
„ ***sulcatum.***
Glyphioceras reticulatum or *crenistria.*

Below high-water mark, 20 yards east of stream, which enters the sea east of Poolvash Farm :—

Posidonomya Becheri.
Solenomya costellata.
Orthoceras Morrisianum.
Orthoceras sp.
Cf. *Glyphioceras reticulatum.*

Nothing new turned up in the black marble quarry.

Mr. Kidston reports that the plants are those which characterise the Calciferous Sandstone group in Scotland, which was the case with the two plants he identified last year from beds of the same horizon in the neighbourhood of Pendle Hill. Unfortunately for the value of plants as zone fossils, this flora is associated in the Calciferous Sandstone group with a totally different fauna from that which obtains at Poolvash, and also the stratigraphical position of the Poolvash shales and Pendle Hill beds admit of no doubt, the deposits resting on the upper beds of the Carboniferous Limestone series.

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[1] Wolterstorf, *Das Untercarbon von Magdeburg-Neustadt und seine Fauna*, 1899.

[2] Von Koenen, *Die Kulm-Fauna von Herborn.*

Of three specimens, doubtfully referred to *Dictyonema*, one was obtained from the Pendleside Limestone series at Hook Cliff, and the others from the plant-beds at Poolvash.

The White Limestones of Poolvash contain a rich fauna identical with that of the upper part of the Limestone Massif at Settle, Cracoe, Clitheroe, and Derbyshire, and belongs to the zone of *Productus giganteus.*

He found the Posidonomya Becheri beds with *Pterinopecten* (*Aviculopecten*) *papyraceus* and *Posidoniella lævis* in the Millbeck, 1½ mile S.E. of Hetton, 1-inch Geological Survey, sheet 92, N.W.

Higher up the stream the Limestone Massif is exposed, and here *Productus giganteus* and a typical fauna were obtained. This is part of the Massif which extends E. and W. from Calton to Greenhow Hill *viâ* Cracoe.

Mr. Tait also collected carefully from the exposures in the River Hodder. It will be remembered that Dr. Henry Woodward described two new species of Trilobites from this locality.[1]

Left bank of Hodder, above Hodder Bridge :—

Chonetes Laguessiana.
Discina nitida.
Productus semireticulatus.
Rhynchonella pleurodon.
Pterinopecten papyraceus.
Posidonomya Becheri.
Solenomya costellata.
Bellerophon Urei.
Orthoceras sp.
Large Goniatite crushed.

Left bank of Hodder, quarter of a mile below Hodder Bridge :—

Phillipsia Polleni.
Prolecanites compressus.

Half a mile S.E. of Hodder Bridge. Cement stones which underlie Pendleside Limestone :—

Phillipsia Polleni.
Cf. *Glyphioceras spirale.*
Productus sp.

River Hodder, 150 yards East of Stoneyhurst Bathing Cots :—

Prolecanites compressus (sutures).
Crassichorda carbonaria (Kidston).
Orthis resupinata.
Productus scabriculus?

River Hodder, east of Bathing Cots :—

Orthoceras annuloso-lineatum.
Prolecanites compressus.
Productus semireticulatus.
Chonetes Laguessiana.
Orthis resupinata.
Oracanthus Milleri.
Plant remains.

River Hodder, near old limekiln, between Hodder Place and the bridge to the south :—

Productus aculeatus.
„ *margaritaceus.*
„ *punctatus.*
„ *semireticulatus.*
Orthis Michelini.
Orthis resupinata.
Spirifer trigonalis.
Phillipsia sp.
A Coral. *Zaphrentis?*

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[1] *Geol. Mag.*, Dec. 4, vol. i. 1894, p. 481.

One mile north of Hodder Bridge :—

Beaumontia Egertoni.
Orthis Michelini.
„ *resupinata.*
Productus aculeatus.
„ *margaritaceus.*
„ *fimbriatus.*
Spirifer trigonalis.
Spiriferina cristata ?
Strophomena analoga.
Orthotetes crenistria.
Spine of Palæchinus.
Posidonomya Becheri.
Nuculana attenuata.

Branch of river Hodder at Agden. West margin of Sheet 92. S.W. of 1-inch Geological Survey :—

Actinoceras giganteum.
Goniatite too compressed to determine.
Athyris ambigua.
Chonetes Laguessiana.
Dielasma hastata.
Edmondia Maccoyi.

Stream running S.W. from Browsholm Hall. East of Sheet 91. S.E. 1-inch Geological Survey, showing section of Pendleside Limestone with flint bands :—

Athyris ambigua.
Chonetes Laguessiana.
Spirifer glaber ?
Posidonomya Becheri.
Aviculopecten prætenuis.
Ctenodonta lævirostris.
Nuculana attenuata.
Glyphioceras bidorsale.
„ *bilingue.*
„ *calyx.*
„ *reticulatum ?*
Cf. *Orthoceras obtusa.*
Phillipsia Polleni.

The River Hodder lies about midway between the Carboniferous Limestone inlier of Withgill and the Millstone Grit of Longridge Fell. The Pendleside series are rapidly attenuating as they pass west. The beds in the Hodder undoubtedly belong to that series, as is shown by the occurrence of the typical Cephalopoda and Lamellibranchiata of the zone in them. I have little doubt but that the bands of Limestone in the Hodder represent the Pendleside Limestone of Pendle Hill.

The Bishopton beds, Glamorganshire, consist of a series of black shales with *Glyphioceras bilingue*, *G. diadema*, *G. reticulatum*, and *Posidoniella lævis*, overlying a series of light-coloured beds of decomposed chert with several fossils, amongst which are

Athyris ambigua.
Chonetes Laguessiana.
Dielasma hastata.
Spirifer glaber.
„ *trigonalis.*
Orthotetes crenistria.
Productus longispinus.
„ *punctatus.*
Productus semireticulatus.
Rhynchonella pleurodon.
„ *pugnus.*
Griffithides Barkei.
Fenestella sp.
„ sp.
Posidoniella lævis.

These light-coloured cherty beds probably represent the uppermost beds of the Carboniferous Limestone series, or even passage beds between this series and the Pendleside beds. It is interesting to note the presence of *Posidoniella lævis* and *Chonetes Laguessiana* and the absence of *P. giganteus* in them.

Last year I examined the upper part of the Carboniferous Limestone series of Weardale with Mr. Barker of Frosterley.

A bed of Quartzose Sandstone above Little Limestone, Wolsingham	*Chonetes Laguessiana*, *Orthotetes crenistria*, *Productus longispinus*, *P. muricatus*, *P. semireticulatus*, *Spirifer ovalis*, *Edmondia sulcata*, *Lithodomus lingualis*, *Bellerophon* (cast), *Naticopsis* (large cast), *Phillipsia Eichwaldi*.
Pattinson's Sill: sandstone 12 feet, shale 24 feet, full of round black concretions at base	*Athyris ambigua*, *Chonetes Laguessiana*, *Rhynchonella trilatera*, *Productus semireticulatus*, *Spirifer glaber*, *S. ovalis*, *S. trigonalis*, *Spiriferina octoplicata*, *Cypricardella Annæ*, *C. rectangularis*, *Bellerophon Urei*, *Orthoceras Morrisianum*, *Zaphrentis* sp., *Crinoid stems*.
Little Limestone, 7 feet . .	*Chætetes radians*, *Syringopora geniculata*, *Cyathophyllum* sp., *Productus longispinus*, tooth of *Cochliodus*.
High and low Coal Sills: Shale a little below Little Limestone	*Discina nitida*, *Productus punctatus*, *Rhynchonella pleurodon*, *Orthotetes crenistria*, *Aviculopecten* sp., *Allorisma sulcata*, *Edmondia unioniformis*, *Nucula gibbosa*, *Nuculana attenuata*, *Protoschizodus axiniformis*, *Bellerophon decussatus*, var. *striatus*, *Pleurotomaria atomaria*, *Orthoceras* sp., *Fenestella* sp., *Crinoid stems*.
Famps or shales, forming upper few feet of Great Limestone	*Athyris plano-sulcata*, *Chonetes Laguessiana*, *Orthis Michelini*, *Productus latissimus*, *Fenestella* and *Crinoids*.
Main, or Great Limestone, 60–70 feet .	*Pisces.—Gyracanthus* spine, *Psammodus porosus*. *Corals.—Lithostrotion basaltiforme*, *Cyathophyllum regium*, *Lonsdaleia floriformis*, *Clisiophyllum* sp., *Chætetes radians*, *C. septosa*, *C. tumidus*, *Syringopora ramulosa*, *Cladochonus* sp. *Brachiopoda.—Dielasma hastata*, *Camarophoria crumena*, *Athyris plano-sulcata*, *Chonetes Buchiana*, *Lingula mytiloides*, *Orthotetes crenistria*, *Orthotetes crenistria*, var. *senilis*, *Orthis Michelini*, *Productus aculeatus*, *P. cora*, *P. fimbriatus*, *P. giganteus*, *P. latissimus*, *P. longispinus*, *P. punctatus*, *P. sinuosus*, *P. semireticulatus*, *Spirifer crassa*, Sp. *lineata*, Sp. *trigonalis*, Sp. *distans*, *Rhynchonella pugnus*, *R. reniformis*. *Lamellibranchs.—Allorisma sulcata*, *A. monensis*, *A. variabilis*, *Edmondia sulcata*, *E. unioniformis*, *Cypricardella Annæ*, *Sanguinolites plicatus*, *Solenomya costellata*, *S. primæva*, *Pinna flabelliformis*. *Gasteropoda.—Dentalium ingens*, *Euomphalus pentangulatus*, *E. catillus*, *Leveillia Puzo*, *Loxonema* sp., *Macrocheilina acuta*, *Naticopsis ampliata*, *N. plicistria*, *Pleurotomaria alta-vittata*, *P. carinata*, Gow., *Bellerophon cornu-arietis*. *Cephalopoda.—Actinoceras giganteum*, *Orthoceras cinctum*, *O. sulcatum*, *Temnocheilus pentagonus*, *Solenocheilus crassiventer ?* *Phillipsia Eichwaldi*.

Mr. J. Dunn, of Redesdale, and I have collected for several years in the neighbourhood of Redesdale—Mr. Dunn continuously—and the following results have been obtained. Most of the fossils have been submitted to various specialists, and the lists give a fairly accurate idea of the fauna found in the two beds, the Redesdale Ironstone and the Four-Laws Limestone above it. Both these beds are probably low down in the Melmerby Scar series, and correspond to the lower part of the

Massif of Carboniferous Limestone. They are low down in the zone of *Productus giganteus*.

—	Redesdale Ironstone and Limestone	Four Laws Limestone at the Coomb
Brachiopoda		
Athyris ambigua	*	
,, Royssii	*	*
Camarophoria crumena	*	
Chonetes Buchiana	*	*
,, Laguessiana	*	*
Discina nitida	*	
Dielasma sacculus	*	*
Lingula mytiloides	*	
,, scotica	*	
,, squamiformis	*	*
Orthotetes crenistria	*	*
Productus aculeatus		*
,, cora	*	*
,, giganteus	*	*
,, longispinus	*	
,, latissimus		*
,, punctatus	*	*
,, scabriculus	*	*
,, sinuatus		*
,, semireticulatus	*	*
,, spinulosus	*	*
,, undatus	*	
Spirifer glaber	*	
,, lineata	*	*
,, ovalis		*
,, striatus		*
,, trigonalis		*
Spiriferina octoplicata	*	
,, var. cristata	*	
Strophomena analoga	*	*
Lamellibranchiata		
Allorisma sulcata	*	*
Cardiomorpha parva	*	
Clinopistha abbreviata		*
,, parvula		*
Conocardium aliforme		*
Ctenodonta undulata	*	
,, lævirostra	*	
Edmondia arcuata	*	
,, Lowickensis		*
,, Maccoyi		*
,, oblonga		*
,, Pentonensis	*	
,, rudis	*	*
,, sulcata	*	*
,, unioniformis	*	
Modiola Jenkinsoni		*
Parallelodon reticulatum		*
Nucula gibbosa	*	
Sanguinolites v. scriptus	*	
,, Visétensis	*	
Sedgwickia ovata	*	
Pinna flabelliformis	*	*
,, mutica	*	
Actinopteria persulcata	*	
Aviculopecten dissimilis	4 sp.	
Streblopteria Redesdalensis		
Gasteropoda		
Eulima Phillipsiana		*
Euomphalus pentangulatus		*
Euomphalus cirrus		*
Loxonema le Febvrei		*
,, rugifera		*
Leveillia puzo		*
Macrocheilus acutus	*	
,, imbricatus	*	*
Murchisonia telescopium		*
Naticopsis implicata		*
,, plicistria		*
Pleurotomaria alta-vittata		*
Pleurotomaria interstrialis	*	
Pleurotomaria decipiens (M'Coy)		*
Platyschizma Zonites	*	*
Dentalium ingens		*
—		
Bellerophon decussata	*	
,, Urei	*	
Conularia quadrisulcata	*	
Cephalopoda		
Orthoceras Gesneri	*	*
,, annulatum	*	
,, attenuatum	*	
,, cylindricum	*	
,, sulcatum	*	
Acanthonautilus bispinosus		*
Glyphioceras truncatum	*	*
,, diadema	*	
Stroboceras bisulcatum	*	
Solenocheilus, *cf.* S. crassiventer		*
Cf. Vestinautilus crateriformis		*
Crustacea		
Dithyriocaris glaber	*	

—	Redesdale Ironstone and Limestone	Four Laws Limestone at the Coomb
Dithyriocaris Dunni	*	
Nuculana attenuata	*	
„ brevirostris	*	
Myalina pernoides	*	
„ Redesdalensis	*	
„ Verneuilii	*	
Protoschizodus axiniformis	*	
Protoschizodus fragilis	*	
Posidoniella elongata	*	
Schizodus axiniformis	*	
Solenomya costellatus		*
Sanguinolites clavatus	*	
„ plicatus	*	
„ striato-granulosus	*	
Sanguinolites tricostatus	*	*
Sanguinolites variabilis	*	*
Dithyriocaris tricornis	*	
Griffithides longispinus		*
Phillipsia gemmulifera		*
„ derbiensis		*
Pisces		
Chomatodus, sp.	*	
Chadodus mirabilis	*	*
Gyracanthus tuberculatus	*	
Petalodus Hastingeri		*
Psammodus porosus	*	
Rhizodus (scales)	*	
Crinoidea		
Ulocrinus nuciformis	*	
Forbesiocrinus, sp.	*	
Scytalecrinus, sp.	*	
Archiocidaris Urei	*	

Report by Mr. J. T. Stobbs, *F.G.S., on his Work in the Pendleside Series, Castleton District, Derbyshire.*

This series forms a passage from the Carboniferous Limestone to the Millstone Grits, and the transition both downwards from the Grits and upwards from the Massif is strikingly shown in this district. The thick grits may be observed to get thinner (and finer in texture), whilst the intervening shales get correspondingly thicker in descending order till the basal sandstone is reached, when the Pendleside series terminates. Starting from the Massif upwards the intermixing of chert beds and limestone may be observed at Little Huckley, the upper limestones being black and unfossiliferous with thin (½ inch) beds of shale intervening. The limestones become separated by greater thicknesses of shales (as at Bradwell) and are frequently represented throughout the entire series either by their unfossiliferous bands, limestone shales, or bullion beds. Lithologically the series is very distinct, being typically black or dark-blue shales except the intervals measured by the limestone bands or bullions which weather a khaki colour. Towards the middle of the series the limestone bands pinch out laterally in a somewhat erratic manner, which detracts from their utility for stratigraphical purposes.

The upper portions of the series are seen in good sections, notably at Mam Tor, the river Noe above Upper Booth and north of Hope, and in the stream called Harden Clough. In the bed of River Noe (which runs in the series from half-mile W. of Lee House to about a mile N. of Hope) the succession is somewhat difficult to make out owing to faulting and folding. The lowest members of the series may be observed near Bradwell village and, I think, in the bed of River Noe from below Edale Mill to ¾ mile E of Booth.

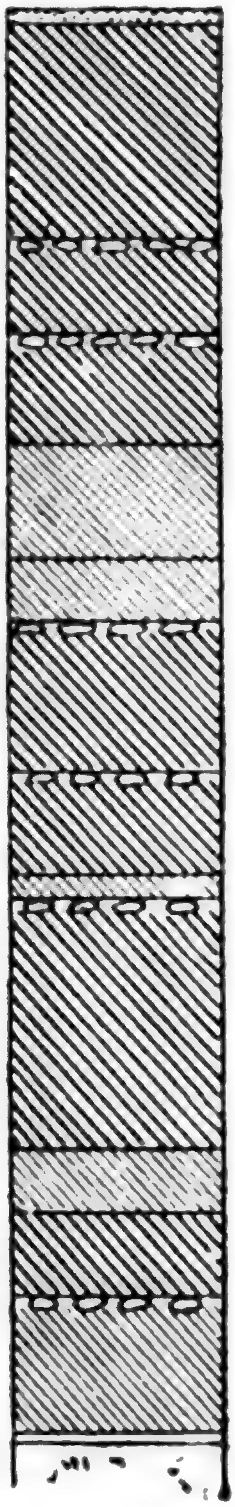
It is somewhat remarkable that these shales should be so frequently found in the bottom of valleys, but this is no doubt due to their being easily scoured out by the streams. Unfortunately they are frequently covered by drift consisting of blocks of grit which have simply rolled from the upper ranges of the hills into the valleys below.

The lithological succession in descending order is—

Grit Series	Thick grits. Sandstones and shales.
Pendleside Series	Shales, often micaceous. Shales with bullions and harder limestone-shales, the latter usually rich in fossils. Brown shales with large bullions and black limestones. Dark-blue limestones and very thin shales.
Carboniferous Limestone	Cherts and limestones. Massif.

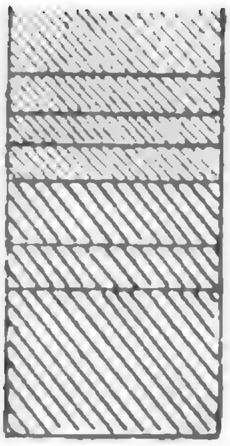
This succession is illustrated by the sections following :—

1. *Mam Tor, E. Face, towards Castleton. ‘C’ and ‘D’ on 6″ Map.*



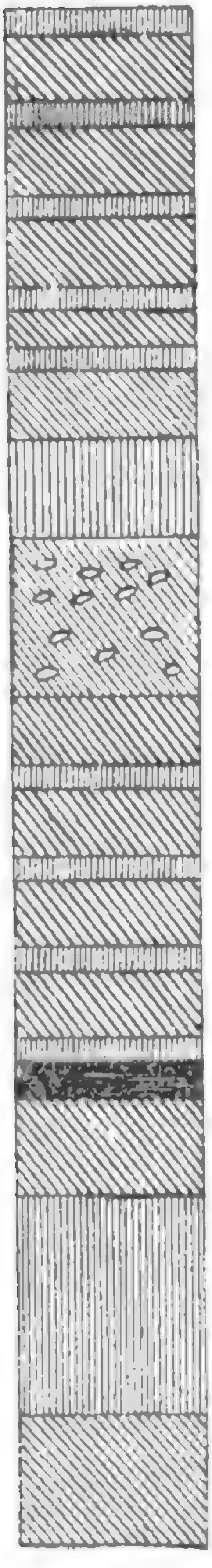
Thickness	″		Locality
0	2	Lowest thin sandstone. Base of grit series.	This relation of Pterinopecten shales to base of grit series is corroborated between Lee House and Edale Head (see 1″ map).
15	0	Black thinly bedded shales. *Posidoniella lævis* (small).	
		Bullion bed.	
6	0	Black shales.	
		Glyphioceras sp.	
		Bullion bed—no Goniatites found in [them.	
10	0	Dark shales, thinly bedded.	
4	0	Blue shales, crowded with *Pterinopecten papyraceus* (very large). *Posidoniella lævis.*	
	1	Limestone shale, crowded with *Pterinopecten papyraceus.*	
		Bullion bed.	
11	0	Black shales.	
		Bullion bed, with Goniatites.	
8	0	Black shales.	
	10	Limestone shales. Goniatites.	
		Bullion bed. Goniatites.	
35	0	Black shales.	
1	0	Limestone shales. *Athyris ambigua. Pterinopecten papyraceus. Glyphioceras spirale.*	
3	0	Black shales.	
		Bullion bed (?). *Dimorphoceras calyx* (numerous).	
10	0	Blue shales. *Posidoniella lævis.*	
	0½	Layer crowded with *Posidoniella lævis.*	

2. *Interval.*

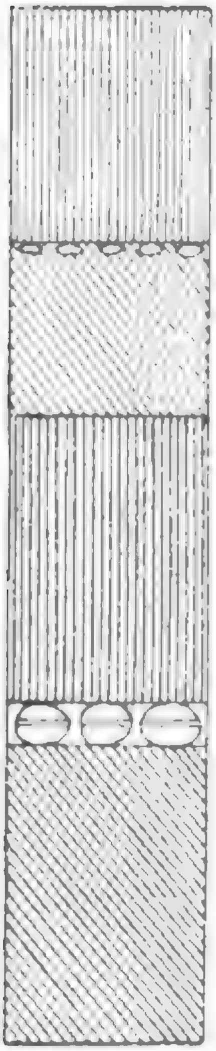


Thickness ′	″		Locality
	8	Blue shale. *Posidoniella lævis*, and reed-like plants.	Section 'A' on 6″ map.
1	8	Friable blue shale.	
	2½	Slickensided shale, showing cleavage.	
1	8	Blue shale, thinly bedded.	
	3½	Dark bituminous shale, (?) *Glyphioceras diadema. G. spirale.*	
	2	Black shale. *Posidoniella lævis.*	
10	0	Dark shales.	

3. *Section on River Noe.*

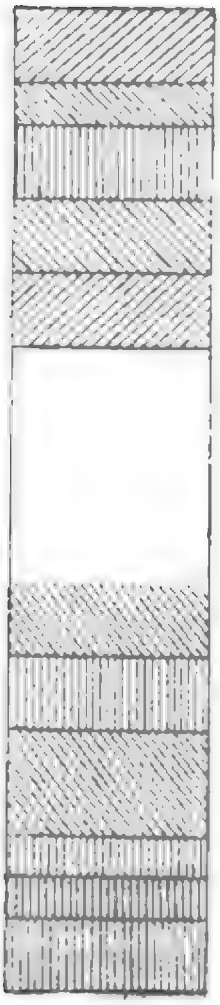


Thickness ′	″			Locality
	3	Limestone shale.		Barber Booth—under figs. 818 on 6″ map.
5	0	Black shale.		
	2	Limestone shale.		
3	3	Black shale, weathering into flaky material, occasional small bullions.		
	3	Limestone (black).		
4	0	Black shale, weathering into fine flakes.		
	1½	Black limestone.		
1	0	Black shale.		
	1	Black limestone.		
2	0	Shale.		
5	3	Limestone shales, rich in fossils. *Glyphioceras bilingue.* Fish. *Pterinopecten papyraceus.*		
(Estimated) 12	0	Shales with bullions.		
6	0	Black shales.	These shales contain very few fossils; only an occasional fish scale.	Between Barber Booth and Railway viaduct.
	2	Black limestone.		
4	0	Black shales.		
		Black limestone.		
6	0	Black shales.		
		Chance band black limestone.		
4	0	Black shales.		
	1	Thin black limestone.		
	1	Lustreless black band.		
6	0	Black shales, with occasional stronger layers.		Railway viaduct.
5	0	Limestone shales, thinly bedded and splitting easily. Fish remains. *Posidonomya membranacea* (large) numerous in lower layers. Glyphioceras. *Posidoniella lævis.* One fragment of *Posidonomya Becheri.*		
12	0	Black shales. *Posidoniella lævis.*		

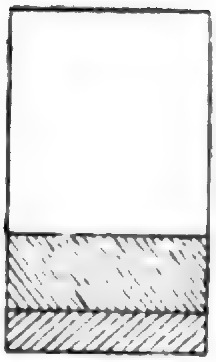


Thickness			Locality
′	″		
15	0	Limestone shales, thicker bedded towards base. *Posidonomya Becheri* (numerous in ½″ layer). 3′ *P. membranacea* (large) numerous. *P. membranacea* (small) abundant in thin layers.	'F' of F.B. near viaduct on 6″ map.
		Large-bullion bed.	Section 'T,' 6″ map.
13	0	Thinly bedded black shales, weathering into fine flakes; no fossils observed.	
(Estimated) 35	0	Strong limestone shales, compact, fine material; few fossils; occasionally *Posidoniella lævis.* Ten feet thickly bedded limestone shales, which ring like a tile when struck with hammer. Six-foot shales with layers of *Posidoniella lævis.*	
		Bullion bed; bullions large, cherty crowded with *Glyphioceras reticulatum*; weathered by water have a dull glaze; in centre of bullions is a thin layer 1″ which weathers white. This layer is parallel to bedding plane.	Marked on 6″ map.
		Thinly bedded black shales.	Base of series seen in this locality.

4. *Section on River Noe.*

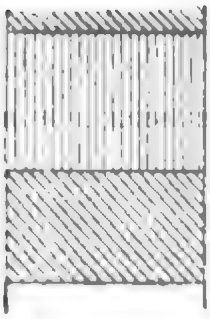


Thickness			Locality
′	″		
3	6	Platy shales.	Section 'I' on 6″ Map.
	4	Shales with reed-like plants.	
	5	Limestone shales. *Posidoniella lævis.*	
	2½	Hard limestone band. *Posidoniella lævis* abundant.	
1	10	Green shales. *Actinopteria persulcata* (numerous). Plants (ferns), *Neuropteris antecedens*, Stur.	
(Estimate) from dip 28	0	Interval.	
		Limestone shales. *Posidoniella lævis.*	Back Tor Bridge.
1	0	Black limestone.	
8	0	Limestone shales. *Posidoniella lævis* (large and numerous).	
1	3	Black limestone. Goniatites.	
	1½	Cherty limestone. Plants.	
		Black limestone shales. *Posidoniella lævis* (small and numerous).	



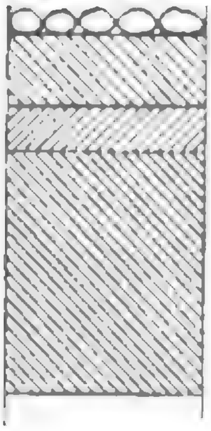
	Thickness '	"		Locality
(Estimated) from dip	28	0	Interval (see note on (5) Section 'P').	
		1½	Limestone shale. *Pteronites angustatus.*	'Q' on 6" Map.
		5	Shale rich in plants.	

5. *Section 'P'—1" and 6" Map. Junction of Stream from South and River Noe.*



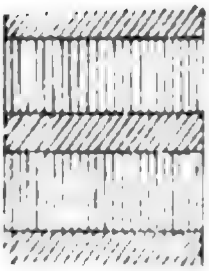
Thickness '	"	
		Black shales. *Posidoniella lævis.*
2	6	Thin, laminated, sub-crystalline limestones. *Phillipsia* sp.; *Productus semireticulatus; Chonetes Laguessiana; ? Spirifer glaber; Discina nitida; Glyphioceras bilingue; ? Prolecanites compressus.*
7	0	Thinly bedded black shales.
		Stronger shales. Orthoceras.

6. *Section at Bradwell (marked 'Lowest Shales' on 1" Map).*



	Thickness '	"	
			Large bullion (4' diameter) in upper portion.
	5	0	Brown, thinly bedded shales. *Glyphioceras bilingue.*
		11	Black cherty limestone.
(Estimated)	30	0	Black shales. *Posidoniella lævis* (numerous in layers).
			Cherts and limestones.

7. *Section at Bradwell 'K' on 1" Map.*



Thickness '	"	
	5	Black chert.
1	3	Dark limestone: fine shell débris. *Phillipsia* sp.
	2	Chert.
2	0	Dark-blue limestone.
		Chert.

Notes on the Sections.

From (1) section it will be seen that a fault (Downthrow, N.) occurs between the main E. escarpment of Mam Tor and the scarp whose section is given. On the N. side of Mam Tor, the first 700 feet are drift covered.

In Harden Clough at the 900-foot contour line shales with reed-like plant-remains are found, frequently with coaly covering. About 30 yards above Harden Clough Farm may be seen a gritty shale with abundant *Glyphioceras bilingue.* About 25 yards below Harden Clough Farm there occurs a thin cemented shale with abundant *Posidoniella lævis.* At the junction of this stream and River Noe a thin black limestone (1 inch) is found: this gives a vertical thickness of about 150 feet.

The position of (6) section relative to the Massif may be calculated. It is taken in a stream 80 yards east of and parallel to the limestone and chert quarry in Bradwell Dale. The limestone and chert beds dip E. about 10°, and the shales are found dipping at the same rate and in the same direction, showing at this place perfect conformability between the two formations. These shales should then be about 30 feet above the chert beds, assuming the top beds of the quarry are the upper cherts.

At the Wortley Mine, Bradwell, these lowest beds of the Pendleside series were sunk through by a shaft, and 'the limestones and cherts were reached 40 fathoms (= 240 feet) from the surface.' The shales and thin limestones on the spoil heap yield *Posidoniella lævis*, *Glyphioceras bilingue*, *Discina nitida*, *Athyris ambigua*, *Rhynchonella trilatera.*

Fossil Zones.—Posidoniella lævis is found practically throughout the series.

Pterinopecten papyraceus is very much more common in the upper shales, and may be considered the commonest fossil in them.

Posidonomya Becheri is a valuable fossil for zoning purposes. It is confined to about 12 feet near the base of (3) section, and is really abundant in a single layer less than 1 inch thick. Associated with it is *P. membranacea*, which is confined to the same beds and is abundant in layers in shales about 12 feet above and 3 feet below the rich *P. Becheri* zone.

Glyphioceras bilingue characterises the lowest members of the series as seen at Bradwell, Barber Booth, and on River Noe, below Booth.

Glyphioceras reticulatum has only been found here in the beds associated with *Posidonomya Becheri.*

G. spirale and *G. diadema* have been found in the upper middle beds of the series at Mam Tor and Peak's Hole Water.

Actinopteria persulcata and Pteronites angustatus have been found abundant in certain shales, in each case overlying plant-beds. They both belong to lower middle beds, and have only been seen at one horizon each.

The association of fossiliferous limestone shales and bullion-beds calls for remark, as it is very commonly found that such shales immediately overlie bullion-beds.

The survival of Phillipsia into the Pendleside age is worthy of note. It is fairly common in the sub-crystalline, thinly bedded limestones shown in section (5).

In conclusion doubtful points may be referred to. The conformability of the Pendleside series to the Massif, as seen at Bradwell, has been mentioned above. Negative evidence in support of the same view is afforded by the fact that nowhere in this area does the Massif form an inlier with different horizons normally in contact.

It is impossible to estimate the thickness of the series, as all the measures are not exposed. To sum up what may be seen—

(*a*) From top shales N. of Mam Tor to top black limestone .	150 feet	(see p. 217)
(*b*) Estimated thickness from base of (*a*) to top of (*c*). .	40 „	
(*c*) Thickness of section (3)	140 „	(see p. 218)
	330	

(*d*) Section (4) shows 74 feet, which is believed to be below (*c*)
(*e*) Section (6) shows 36 feet

110 feet

Total thickness open to investigation, 440 feet.

A List of the Fish Fauna of the Pendleside Limestones, with Remarks on the Evidence which may be adduced from such List in support of the Systematic Position of the Rocks. By EDGAR D. WELLBURN, *F.G.S., &c.*

Remarks on the List.

On glancing through a list of the fossil fishes of the Pendleside Limestones, one is at once struck with the great similarity of the fauna to that of the Millstone Grits, and through them, to a great extent, to that of the Lower Coal Measures above. On the other hand, when we compare the list with that of the true Yoredales (Phillips) and the Mountain Limestones below, the great dissimilarity is at once apparent, there being a decided and great break in the fauna of the two groups of rocks, the dividing line being at the base of the Pendleside Limestones; and this being so, in my opinion, the division of the Carboniferous rocks should be at the base of the Pendlesides, they being classed along with the Millstone Grits and Coal Measures in the Upper Carboniferous, whereas the true Yoredales and Mountain Limestones should constitute the lower division.[1]

If we go into the matter more closely, and take the genera in the list and compare them with those found in the rocks above, we find that the following pass up into these rocks, but are not found in the true Yoredales and Mountain Limestones below, viz., Acanthodes, Marsdenius, Strepsodus, Rhizodopsis, Cœlacanthus, Rhadinichthys, Elonichthys, Acrolepis, and Platysomus.

Again, the genera Cladodus and Orodus are very rare in the Pendlesides and Millstone Grits, but very plentiful in the rocks below, and they appear to have rapidly died out and become extinct in the Upper Carboniferous rocks; and yet again, although I have found the Lower Carboniferous genera Psephodus, Pristodus, and Pœcilodus in the Millstone Grits (but not in the Pendlesides), still they (the teeth) are extremely rare when compared with the other genera, as I have only found a single specimen of each. They are also of small size—when compared with those found in the Lower Carboniferous rocks, where they are very abundant—and the fishes appear to have become extinct in the Millstone Grits; as far as I know they have not been found in the Coal Measures above.

Many of the fossils have been too fragmentary to be worth preservation. A complete series has been sent to the Geological Museum,

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[1] It is the writer's intention to deal more fully with this subject later.

A List of the Fish Fauna of the Pendleside Limestones, with their Distribution.

	Pule Hill, Marsden, Yorkshire	Crimsworth Dean, Yorkshire	Todmorden, Yorkshire	Whitewell, near Clitheroe, Yorkshire	Dane Valley, Staffordshire	Banks of River Hamps, near Waterhouses, Staffordshire	Dove Holes Tunnel, Buxton	Burnsall and Thorpe Fell, Yorkshire	Astbury, near Congleton, Cheshire	North Derbyshire
1. Cladodus mirabilis (Agassiz) . .		*								
2. " sp. ? . . .							?	*	*	
3. Orodus elongatus (Davis). . .	*	*							*	
4. Acanthodes, sp. ?	*				*				*	
5. Marsdenius Summiti, g. et sp. (Wellb.)	*									
6. " acuta (Wellburn) . .	*									
7. " sp. ?					*					
8. Strepsodus sauroides (Birney) . .	*									
9. Rhizodopsis sauroides (Williamson) .	*									
10. Cœlacanthus Hindei (Wellburn) .						*				
11. " sp. ?										*
12. Rhadinichthys circulus (Wellburn) .										*
13. " sp. ?	*				*					
14. Elonichthys Aitkeni (Traquair) .	*	*								
15. " sp. nov. ? . . .	*									
16. " obliquus (Wellburn) .	*		*							
17. Acrolepis Hopkinsi (M'Coy) . .	*	*			*					
18. Platysomus, sp. ?				*						

University College, London, where Professor Garwood has offered to exhibit and store them. Some few duplicates are still in the Secretary's hands for purposes of comparison. The Lamellibranchs and Brachiopoda from Eccup, collected some years ago, have been determined and sent to University College. Very few museums, if any, possess specimens of the Pendleside fauna, and practically no fossils from the alternating limestones and shales of the Yoredale phase of the Carboniferous Limestone are exposed.

The thanks of the Committee are due to Mr. R. Kidston, F.R.S., Dr. A. H. Foord, and Dr. Wellburn for work done on the collections, and for furnishing reports which are incorporated herein, and to Mr. J. Dunn for allowing me to make use of his collections in compiling the fauna of the Redesdale and Four Laws Limestone; to Mr. J. Barker for similar help in Weardale.

The balance of 5*l.* left over from last year has been spent, together with the greater part of the grant of 10*l.* made at the last meeting, leaving only a few shillings balance. It is to be hoped that a liberal grant will again be forthcoming. The Secretary proposes that detailed work be commenced on the various limestone and shales of the western escarpment of the Pennine series, together with an examination of the quarries in the lower part of the Limestone Massif in Derbyshire, to ascertain if any fossils appear to be restricted to certain beds or horizons. The Secretary also hopes to obtain an accurate list of the Culm fauna of Devonshire, the similarity of the Pendleside and Culm faunas being most striking.

The Movements of Underground Waters of North-west Yorkshire.—Third Report of the Committee, consisting of Professor W. W. WATTS (*Chairman*), Mr. A. R. DWERRYHOUSE (*Secretary*), Professor A. SMITHELLS, Rev. E. JONES, Mr. WALTER MORRISON, Mr. G. BRAY, Rev. W. LOWER CARTER, Mr. T. FAIRLEY, Mr. P. F. KENDALL, *and* Mr. J. E. MARR.

PLATE II.

THE Committee is carrying out the investigation in conjunction with a committee of the Yorkshire Geological and Polytechnic Society.

On referring to the last report of this committee it will be seen that on September 5, 1901, three quarters of a pound of fluorescein was put into the water flowing down Long Churn, near Alum Pot, at 4 P.M., and that a further quantity of three quarters of a pound was introduced at 5.30 P.M. on the same day. At the time of writing the last report the outflow of this had not been observed; but it has since been learned that it issued from Turn Dub, on the opposite side of the River Ribble, and close to the bank of that stream, on September 17. The water therefore took twelve days to accomplish a journey of 1½ mile.

The extreme slowness of the flow is partly to be accounted for by the dry weather which then prevailed; but when it is taken into consideration that the water of Long Churn plunges down a very steep fall into Alum Pot, the total depth of which is some 300 feet, the gradient of the remainder of the stream is considerably reduced.

The Secretary was informed by Mr. Wilcox, of Selside, that the fluorescein mentioned above had been seen in Footnaw's Hole prior to its appearance at Turn Dub.

The relative positions of Long Churn, Alum Pot, Footnaw's Hole, and Turn Dub will be seen by reference to the map (Plate II.).

In dry weather Footnaw's Hole appears as a wide cleft in the limestone, with sloping banks of silt and sand round two sides and precipitous limestone rocks on the other two. When the streams are in flood after heavy rain or during the melting of snow the water in Footnaw's Hole rises to the lip and flows over down Footnaw's Beck into the Ribble.

Turn Dub is very rarely dry, while it is only in exceptionally wet weather that water flows from Footnaw's Hole.

Thus it would appear that Footnaw's Hole is a flood outlet, and only comes into operation when the underground passage leading to Turn Dub is full and therefore unable to take the excess of water. As the lip of Footnaw's Hole is just below the 1,225-foot contour, and Turn Dub just below that of 1,200 feet, there cannot be a fall of more than 25 feet from the former to the latter.

Further, since in ordinary weather, when the stream is issuing from Turn Dub only, the water in Footnaw's Hole stands some 20 feet below the ground level, it will be seen that there must be a siphon-like passage below the river; and since this passage must be constantly filled with water up to the level of the overflow of Turn Dub, it will account for the very slow passage of the fluorescein over at least this part of the journey.

Since the water passes beneath the River Ribble it follows that there must be some impervious cover, because if this were not the case the water of the underground stream would find an escape at the lowest point—namely, in the bed of the river—and would not, as is the actual case, pass under that stream and rise some 10 or 12 feet above it on the opposite bank.

With a view to ascertaining the nature of this impervious cover and its thickness it was determined to carry out a series of boring operations in the alluvial flat between Turn Dub and the river.

In the first place Turn Dub was sounded and found to be only about 18 feet in depth. Now Turn Dub is a circular pond of still water, and although a large stream of water flows out there is no disturbance of the surface, nor welling up of the water apparent. This would lead one to suppose that the pool was much deeper than is actually the case. So far as could be ascertained by drawing the sounding-iron across the bottom of the pool, this consists of large boulders. This led your Committee to suspect that the cover consisted of boulder clay, and that the bottom of Turn Dub consisted of boulders, the clayey matrix having been removed by the action of the flowing water.

The boring operations were undertaken with a small set of hand boring-rods provided with an auger bit.

With this apparatus it was possible to prove that the bluish alluvial clay was underlain by a material consisting of a somewhat sandy-brown clay with many large stones, and in every way similar to the boulder clay of the neighbourhood, which in some places can be seen close to the river-bank.

The presence of numerous boulders prevented the boring operations being carried more than a matter of 1 or 2 inches into the boulder clay, so that it was impossible to obtain any definite evidence regarding the thickness of the bed.

Further, although boulder clay was proved to underlie the alluvium on both banks of the Ribble, it was impossible to obtain evidence of its existence in the river-bed, as this consists of coarse shingle which could not be penetrated by the hand-boring apparatus.

In order to clear up this matter satisfactorily it will be necessary to engage the services of a professional well-sinker and to have one or two boreholes put down by mechanical means.

Investigation of the Streams tributary to, or in the neighbourhood of, Alum Pot.

A series of small springs rises beneath the drift and peat near the wall at the north end of Whit-a-Green: these run together and form a small stream which sinks at P 34, a small pot-hole amongst long grass. Fluorescein was introduced here and reappeared in half an hour at a small opening some hundred yards to the south of P 34: here the stream can be traced on the surface for 20 yards, when it again sinks.

The fluorescein was put into P 34 at 4 P.M., and was traced the following day at S 52; then overground to P 35, where it again sank to reappear at S 49; thence it flowed to P 36, and so underground to S 50, finally sinking at P 41.

The fluorescein sinking at P 41 did not affect any of the springs on Font Green, but was again seen in Footnaw's Hole.

This water must therefore go by a deep course, and eventually join the underground flow from Alum Pot to Turn Dub, *viâ* Footnaw's Hole.

Whit-a-Green Spring.—This rises on the higher slopes of Simon Fell at a height of 1,600 feet, and flows over the surface of the rocks of the Yoredale Series till it reaches the underlying Carboniferous limestone at 1,250 feet, where it sinks at P 29.

A trial with fluorescein resulted in proving that this water flows out at S 55 and falls into the middle opening of Long Churn, known as Dickon Pot, P 30, where it joins the main stream occupying that channel.

The channel by which this stream flows can be traced for a considerable distance by means of a series of openings to the surface, and it was found to be possible to actually traverse the tunnel throughout almost its entire length; but the exploring party was eventually stopped by the roof coming down to the water level.

Small Spring to the North-east of last (S 53).—There is never much water in this spring, and it is quite dry in seasons of drought. It probably derives its water from the peat at its head.

The water sinks at P 28 and issues, as proved by a fluorescein test, at S 55, along with the water from P 29.

The underground junction of these two streams was afterwards traced, though it was found to be impossible to follow the whole length of the passage, the roof being too low, and there being deep pools of water lying in the bottom.

It may be mentioned in passing that as this was a short run methylene blue was tried for the test, but although only a small quantity of water was flowing at the time it was not seen at S 55; one-fourth the quantity of fluorescein, however, succeeded two hours later.

This, together with the failure of methylene blue to put in an appearance when used at Grey Wife Sike, as mentioned in the second report of this committee, demonstrates conclusively the superiority of fluorescein for purposes of this nature.

Long Churn Spring.—This rises on the upper slopes of the fell and sinks on Borrin's Moor at P 42, and after a very short underground course issues at S 57, forming, however, only a very insignificant part of that spring.

The next series of experiments had for its object the discovery of the source of the bulk of the water at S 57.

On examining the upper part of Alum Pot Beck it was found that a large part of that stream sank at P 33, and fluorescein introduced here was seen at S 57 within an hour.

P 26 was the next point of experiment, and by a series of trials with fluorescein it was found that the water flowed underground along a well-marked line of joint to P 43 *a*.

This line of joint is well marked both by crevices in the clints and by a line of pot-holes, in some of which the water shows itself. It runs N. 18° W.

At P 34 *a* the water falls into another open joint, running N. 25° E., which leads it to S 51, whence it runs over the surface to P 43, again beneath the surface to S 40, and then on to S 42 and P 37, where it again disappears.

At the time of these experiments the greater part of the water was sinking in the bed of the stream at P 37 *a*, but a little was flowing on to P 37 near the old limekiln.

Fluorescein put into the stream just above P 37 *a* came out at P 38, where it again sank and reappeared half an hour later almost simultaneously at S 43 and S 44.

It was then traced to P 39, where it again went underground to issue at Font Green Spring, S 45.

At P 40 part of this stream sinks (the whole of it in dry weather) to reappear at S 46, and part flows over the surface, the streams when reunited forming Selside Beck, which runs through the village of Selside and on into the River Ribble.

The above streams occupy a wide valley and would, with the exception of Gill Garth Beck (P 26 to P 37), all drain into Selside Beck were they not swallowed into cracks in the limestone.

There would appear to be two distinct sets of channels below Font Green—a deeper and a more superficial one.

The water flowing by the deeper channel—viz., that from Alum Pot, Long Churn, and P 41—reaches the Ribble by way of Footnaw's Hole and Turn Dub, while the shallower set issues on Font Green and joins Selside Beck.

Many of the underground stream courses are accessible and may be followed for long distances with the aid of short ladders, provided the explorer does not object to getting wet and doing a certain amount of crawling in the less lofty portions.

It was laid down in the two previous reports of this Committee that as a general rule the flow of underground water in limestone rocks follows the direction of the master joints, and this view has been strikingly confirmed by several of the experiments which have been carried out during the current year.

It was seen that in the open passages in the neighbourhood of Pot was an opportunity for putting this theory to the practical t following the water step by step in its underground journeyings.

With this object in view your Committee undertook to make a vey of some of the more readily accessible channels, with the foll results.

A plan of the series of passages communicating with Long Churn joining that opening with Alum Pot was constructed, and this wi published in due course by the Yorkshire Geological and Polyte Society.

On this plan the directions of the principal lines of jointing been marked for purposes of comparison with the direction of caverns.

It may be confidently said that there is a general parallelism betw joints and passages, but this is by no means so close as was at expected.

To account for the want of parallelism between joints and pass it is necessary to study the evolution of one of these undergro chambers.

The joints in the limestone undoubtedly give the initial direction the underground stream ; but as soon as a channel is formed sufficien large to allow of a free flow of water, as opposed to mere soakage, number of other forces come into play which tend to modify the directi so as to cause it to diverge somewhat from its original one of str parallelism to the joints.

For example, the dip of the rocks causes the erosion of the chann to be more severe on one side than the other—namely, on the low 'down dip' side—and where there are cross-joints the dip may tend produce a lateral escape along one of these so as to give rise to a zigz course.

Up to a certain point the erosion in these underground river channel is entirely by solution, but so soon as the external opening becomes su ficiently large to admit sand gravel and boulders excavation by means attrition comes into play.

At this point in the history of a subterranean river zigzags ar changed into sharp windings, which in their turn impart a swing to th waters in the straight parts, thus causing a series of windings to be se up in a manner similar to that which goes on in surface streams.

As the external opening which gives access to the water increases in size, so does the amount of water flowing through the passage increase. An increase of volume means an increase of speed and a lessened tendency to winding ; at the same time the passage must be widened so as to accommodate the increased volume of the stream.

The tendency at this stage is, then, to widen and straighten out the passages, and many are the deserted 'ox-bows,' both large and small, which may be seen in the passages.

Some of these are small and situated at a considerable height above the floor of the main passage, while others of more recent formation are approximately at the same level as the water-bearing passage, a few of them still being occupied by a portion of the stream in times of flood.

The condition of approximate stability is reached when the opening becomes sufficiently large to swallow the whole of the surface stream.

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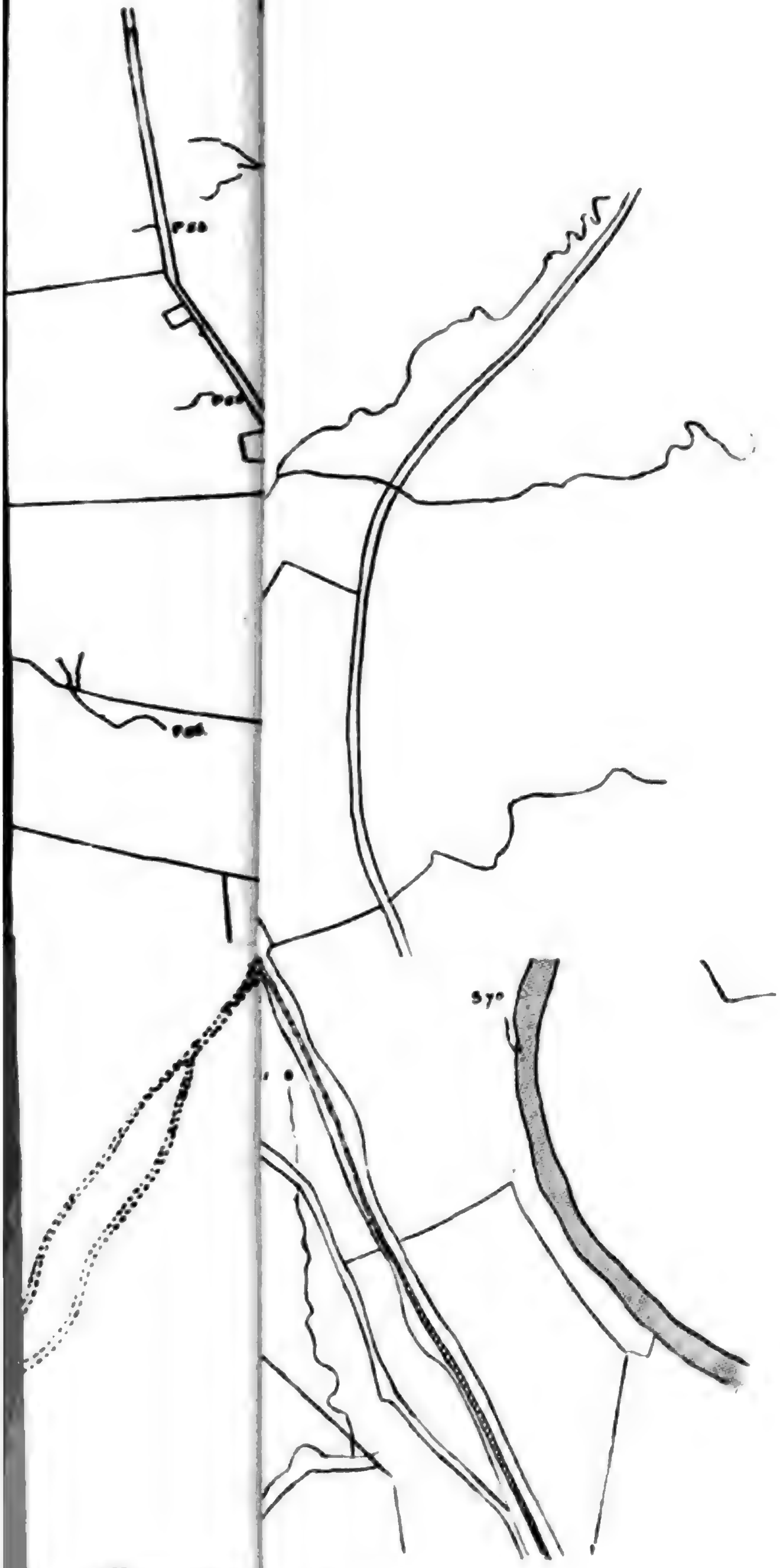

Illustrating

On the occasion of their last visit to the district your Committee hurriedly explored a cave which they had not previously seen, and are of opinion that it offers remarkable facilities for the further study of the development of underground watercourses, inasmuch as it exhibits tributary and deserted passages in every stage of development and decay.

In order to enable them to further prosecute the study of this most interesting question your Committee hopes that it will be granted a new lease of life, and therefore asks to be reappointed with a further grant.

The members of the Committee wish to tender their thanks to Mr. Theodore Ashley, of Leeds, mine surveyor, who, though not a member of either of the committees, has given much time and care to the investigation.

Photographs of Geological Interest in the United Kingdom.—Thirteenth Report of the Committee, consisting of Professor JAMES GEIKIE (*Chairman*), Professor W. W. WATTS (*Secretary*), Professor T. G. BONNEY, Professor E. J. GARWOOD, Dr. TEMPEST ANDERSON, Mr. GODFREY BINGLEY, Mr. H. COATES, Mr. C. V. CROOK, Mr. J. G. GOODCHILD, Mr. WILLIAM GRAY, Mr ROBERT KIDSTON, Mr. A. S. REID, Mr. J. J. H. TEALL, Mr. R. WELCH, Mr. H. B. WOODWARD, *and* Mr. F. WOOLNOUGH. (*Drawn up by the Secretary.*)

THE Committee have to report that during the year 412 new photographs have been received, bringing the total number in the collection to 3,308. This is the largest number of new photographs ever recorded in a single year, and the annual average number of photographs recorded for each of the thirteen years of the Committee's existence now reaches 254.

The usual geographical scheme is appended. There are no new counties in the list, but the following are now very well represented :—Cumberland, Devon, Gloucester, Leicester, Somerset, and Westmorland, while Suffolk, Glamorgan, Banff, Fermanagh, and Sligo are beginning to be better illustrated. There are, however, several counties, many of them mentioned in previous reports, still entirely unrepresented in the collection.

Several improvements are noticeable in this year's accessions. In the first place, instead of isolated photographs the Committee are receiving an increasing proportion of groups, each illustrating some special point, some defined area, or some particular piece of work. Thus Mr. Bingley sends a series illustrating Professor Kendall's work on the Glaciation of the Cleveland Hills, recently published by the Geological Society. He also continues his Yorkshire Coast series and those from the Magnesian Limestone district. Mr. A. S. Reid's set shows the development of joint-caves by marine denudation. Charnwood Forest is the subject of most useful sets by Dr. Meadows, Mr. Harrison, Mr. Hodson, Mr. Coomáraswámy, and Mr. Levi. The Geologists' Association excursions have also produced a Gower series by Mr. Coomáraswámy, and numerous isolated prints by himself and other geologists. Professor Reynolds sends sets taken along a new railway in Gloucestershire, and groups from South Devon, Gloucestershire, and Somerset.

—	Previous Collection	Additions (1902)	Total
ENGLAND—			
Cornwall	42	8	50
Cumberland	18	21	39
Derbyshire	41	3	44
Devon	135	40	175
Dorset	99	2	101
Durham	111	6	117
Essex	3	3	6
Gloucestershire	24	27	51
Hampshire	19	17	36
Kent	72	7	79
Lancashire	67	1	68
Leicestershire	93	45	138
Middlesex	3	4	7
Shropshire	44	7	51
Somerset	47	19	66
Staffordshire	51	2	53
Suffolk	10	11	21
Surrey	43	4	47
Warwickshire	38	1	39
Westmorland	62	16	78
Worcestershire	19	7	26
Yorkshire	456	88	544
Others	215	—	215
Total	1,712	339	2,051
WALES—			
Glamorganshire	12	29	41
Montgomeryshire	10	1	11
Others	172	—	172
Total	194	30	224
CHANNEL ISLANDS	15	—	15
ISLE OF MAN	60	—	60
SCOTLAND—			
Banffshire	4	7	11
Lanarkshire	7	4	11
Orkney and Shetland	1	2	3
Perthshire	20	2	22
Others	279	—	279
Total	311	15	326
IRELAND—			
Antrim	226	13	239
Donegal	45	5	50
Down	86	2	88
Dublin	27	6	33
Fermanagh	4	1	5
Sligo	4	1	5
Others	116	—	116
Total	508	28	536
ROCK STRUCTURES	96	—	96

—	Previous Collection	Additions (1902)	Total
ENGLAND	1,712	339	2,051
WALES	194	30	224
CHANNEL ISLANDS	15	—	15
ISLE OF MAN	60	—	60
SCOTLAND	311	15	326
IRELAND	508	28	536
ROCK STRUCTURES	96	—	96
Total	2,896	412	3,308

To the same category belong also Mr. Harrison's Isle of Wight se and his series illustrating Pliocene and Pleistocene rocks in Suffolk. The Croydon Scientific and Natural History Society, through Mr. Robarts, continues its illustrations of local geology, a work which in future will presumably be carried on by the recently inaugurated county survey of Surrey on a larger scale. The Philosophical Society of the University of Durham also sends, through Mr. D. Woolacott, photographs in continuation of its former work in its county.

Mr. Welch is continuing his admirable task of illustrating Irish geological features, and sends beautiful sets of platinotypes from Antrim, Donegal, Down, Dublin, Fermanagh, and Sligo. Mr. Watson contributes well-taken illustrations of Carboniferous trees.

In the second place, an increasing number of photographs are now so well taken and from such advantageous points of view that they tell their own story and depend much less on description than hitherto.

Again, the photographs are of a more serious geological character than ever before, and, although many of them are pretty pictures as well, they illustrate important and typical geological phenomena and features really worthy of record. In some cases new discoveries and facts very difficult of portrayal are attempted and with considerable success.

Lastly, unusual care has been taken in the descriptions; and although these undoubtedly impose a tax on the photographers' time and patience, they add very greatly to the permanent value of the photographs.

In addition to the larger sets specified above, especial mention should be made of the following:—Messrs. G. V. and H. Preston's and Mr. Reid's Cornish Raised Beaches; Mr. Wrench's examples of glaciation in Derbyshire; Mr. Monckton's sets from Essex, Kent, Surrey, and Yorkshire; Mr. Robinson's pretty set from Yorkshire, and Mr. Metcalfe's very choice trio from Antrim.

To all the gentlemen mentioned above the very best thanks of the Committee are due, and also to the following, who have helped by contributions and other assistance: Mr. E. Pierce, Mr. Wheen, Mr. C. H. Topham, Mr. J. H. Baldock, Mr. W. G. Fearnsides, Mr. G. T. Atchison, Mr. W. J. Forrest, Mr. C. J. Watson, Mr. J. Barrowman, Mr. W. H Beeby, and Miss M. K. Andrews.

The Committee would be glad if all contributors would make use of local numbers as a key to their photographs. The method has several advantages. In addition to being a means of identification by the Secretary it enables contributors to recognise their prints in the list and to affix the B.A. number to their negatives. Also, if the number is placed right way up on the photograph, it affords a useful and sometimes needed guide in mounting it. But it has a further use, which is much more appreciable now that the collection and accessions are so large, and that less accessible and less known districts are being photographed; by grouping his numbers the contributor can help the Committee in the difficult task of grouping the prints for mounting, a most important thing when large series have to be dealt with from a district not personally known to the Secretary or his friends.

Although a few photographs and slides for the duplicate series have been received during the year, notice of them is withheld for the present.

The duplicate collection has been sent to natural history societies at the following places: Birmingham, Bristol, Croydon, Belfast, and Leeds.

The first issue of the published series of geological photographs has now reached the subscribers. Twenty-two prints and slides taken from negatives lent by thirteen contributors have been issued, accompanied by printed descriptions written by fourteen geologists. To contributors and subscribers the Committee wish to give their best thanks. The Secretary has received many kindly expressions of satisfaction from the subscribers, amongst whom are many foreigners living all over the world.

It is hoped that the second issue will be complete within this year, as the selection has already been made and some of the work is in hand.

Applications by Local Societies for the loan of the duplicate collection should be made to the Secretary. Either prints or slides, or both, can be lent, with a descriptive account of the slides. The carriage and the making good of any damage to slides or prints are expenses borne by the borrowing society.

The Committee recommend that they be reappointed, with a small grant, and that Professor S. H. Reynolds, Mr. A. K. Coomáraswámy, and Mr. J. St. J. Phillips be added to their number.

THIRTEENTH LIST OF GEOLOGICAL PHOTOGRAPHS.

(To August 27, 1902.)

This list contains the geological photographs which have been received by the Secretary of the Committee since the publication of the last report. Photographers are asked to affix the registered numbers, as given below, to their negatives for convenience of future reference. Their own numbers are added in order to enable them to do so.

Copies of photographs desired can, in most instances, be obtained from the photographer direct, or from the officers of the local society under whose auspices the views were taken.

The price at which copies may be obtained depends on the size of the print and on local circumstances over which the Committee have no control.

The Committee *do not assume the copyright of any photographs* included in this list. Inquiries respecting photographs, and applications for permission to reproduce them, should be addressed to the photographers direct. It is recommended that, wherever the negative is suitable, the print be made by the cold-bath platinotype process.

The very best photographs lose half their utility, and all their value as documentary evidence, unless accurately described; and the Secretary would be grateful if, whenever possible, such explanatory details as can be given were written on the forms supplied for the purpose, and *not on* *the back of the photograph or elsewhere.* Much labour and error of transcription would thereby be saved. It is well, also, to use a permanent ink for this purpose. A local number by which the print and negative can be recognised should be written on the back of the photograph and on the top right-hand corner of the form.

Copies of photographs should be sent *unmounted* to W. W. Watts, The University, Birmingham, and forms may be obtained from him.

The size of photographs is indicated as follows :—

L = Lantern size.
1/4 = Quarter-plate.
1/2 = Half-plate.
1/1 = Whole plate.
10/8 = 10 inches by 8.
12/10 = 12 inches by 10, &c.
E signifies Enlargements.

* Indicates that photographs and slides may be purchased from the donors, or obtained through the address given with the series.

LIST I.

ACCESSIONS IN 1901-1902.

ENGLAND.

CORNWALL.—*Photographed by* A. S. REID, *M.A., F.G.S., Trinity College, Glenalmond, Perth.* 1/4.

Regd. No.			
3255	(P.T. 5)	Pendora Beach, Gerran Bay.	Raised Beach. 1900.
3256	(P.T. 4)	" " "	" " "

Photographed by G. V. *and* H. PRESTON, *Alverne House, Penzance.* *R. H. PRESTON, *Penzance.* 1/1 *and* 5/4.

2880	( )	Porthmeo Cove, Zennor .	Granite vein intersecting and shifting another. 1896.
2881	( )	Porth Nanven Cove, St. Just.	Raised Beach. 1900.
2882	( )	" " "	Raised Beach, looking N. 1900.
2883	( )	" " "	" " S. "
2884	( )	" " "	" " E. "
2885	( )	" " "	‘Head’ covering Raised Beach. 1900.

CUMBERLAND.—*Photographed by* GODFREY BINGLEY, *Thorniehurst, Headingley, Leeds.* 1/2.

2886	(5622)	Head of Dunmail Raise.	Stream dividing on Cone of Dejection. 1901.
2887	(5623)	Thirlmere, from Dunmail Raise.	Moraine from Wythburn Valley. 1901.
2888	(5624)	" " "	Dunmail Raise in distance. "
2889	(5628)	Threlkeld Granite Quarry.	Jointing in Microgranite. "
2890	(5627)	" " "	" " "
2891	(5629)	" " "	" " "
2892	(5630)	" " "	" " "
2893	(5631)	" " "	" " "
2894	(5655)	Summit of Carrock Fell.	Weathered Granophyre. "
2895	(5653)	Eycott Hill . . .	Hypersthene Dolerite. "
2896	(5652)	" "	" "
2897	(5651)	Great Mell Fell, Troutbeck.	Basement Beds of Carboniferous Limestone. 1901.

Regd. No.				
2898	(5642)	Honister Pass . .	Looking down.	1901.
2899	(5644)	" "	" up.	"
2900	(5637)	Grange Bridge, Borrowdale.	Striated *roche moutonnée*	"
2901	(5636)	Grange Bridge, Borrowdale.	" " "	"
2902	(5634)	Derwentwater . .	Delta.	"
2903	(5633)	Syning Gill, Skiddaw .	Contact, altered Slate and Granite	"

Photographed by A. K. COOMÁRASWÁMY, *B.Sc., F.G.S., Walden, Worplesdon, Guildford.* 1/4 *and* 1/1 E.

2904	( )	Seathwaite, Borrowdale .	Lateral Stream entering valley at high level. 1900.
2905	( )	Above Sty Head Tarn, Borrowdale.	Block of 'Snaky Ash.' 1900.
2906	( )	From above King's Head, Thirlspot.	Skiddaw and Saddleback. 1900.

DERBYSHIRE.—*Photographed by* A. WHEEN, *Baslow, and presented by* E. M. WRENCH, *Park Lodge, Baslow.* 1/2.

2907	(1)	North-east corner of Chatsworth Park.	Striæ on Millstone Grit Boulder.	1900.
2908	(2)	North-east corner of Chatsworth Park.	Mammillated Gritstone Boulder.	"
2909	(3)	North-east corner of Chatsworth Park.	" " "	"

DEVONSHIRE.—*Photographed by* Professor S. H. REYNOLDS, *M.A., F.G.S., University College, Bristol.* 1/2 *and* 1/4.

2910	(13)	Near Rousdon . . .	Cliff of Upper Greensand and Chalk.	1900.
2911	(14)	East of Rousdon . .	Upper Greensand and Lower Lias.	"
2912	(9)	Near Rousdon . . .	Landslip.	"
2913	(8)	" " . . .	"	"
2914	(15)	Rousdon Landslip . .	Chalk, with hard foraminiferal lumps.	"
2915	(10)	Coast, near Pinhay . .	Lower Lias and White Lias.	"
2916	(11)	Between Pinhay and Lyme	Lower Lias.	"
2917	(12)	East of Pinhay . . .	" "	"
2918	(16)	Thurlestone Sands . .	Permian Conglomerate.	1901.
2919	(17)	" " . .	Unconformity, Permian on Devonian.	"
2920	(20)	Inner Hope, Bolt Tail .	Contorted Mica-schist.	"
2921	(23)	" " " .	" "	"
2922	(25)	Batson Creek, Kingsbridge	Weathered 'Hornblende-epidote-schist.'	"
2923	(27)	" " " .	" contorted 'Mica-schist.'	"
2924	(21)	Start Point . . .	Rugged weathering of Mica-schist.	"
2925	(48)	West of Torcross . .	Quartz-veins.	"
2926	(19)	" " . .	Contorted Quartz-vein.	"
2927	(24)	" " . .	Weathered surface of contorted Devonian Rocks. 1901.	
2928	(26)	" " . .	Weathered surface of contorted Devonian Rocks. 1901.	
2929	(22)	Near Hotel, Torcross .	Igneous bands (?) in Devonian Slate.	1901.
2930	(28)	Shore, east of Paignton .	'Head' capping New Red Sandstone.	"
2931	(31)	" " " .	Marine denudation of New Red Sandstone. 1901.	
2932	(29)	Shore, near Torquay Station	Step-fault in New Red Rocks.	1901.
2933	(30)	" " " .	Marine denudation along joints and bedding-planes in New Red Sandstone. 1901.	

Regd. No.		
2934	(37) South of Natural Arch, Torquay.	Coralliferous Devonian Limestone. 1901.
2935	(38) South of Natural Arch, Torquay.	" " " "
2936	(36) Daddy Hole, Torquay .	Ravine due to slipping of Devonian Limestone. 1901.
2937	(39) Near Natural Arch, Torquay	Crushed Devonian Limestone. 1901.
2938	(45) Natural Arch, Torquay .	Inverted " " "
2939	(42) Thunder Hole, Torquay .	Natural Arch. "
2940	(43) Meadfoot Bay, Torquay .	Cleavage and Bedding in Devonian. "
2941	(34) Hope's Nose, Torquay .	Blocks at base of Raised Beach. "
2942	(44) " " " .	Contorted Devonian Slate and Limestone, 1901.
2943	(40) Top of north descent into Anstie's Cove, Torquay.	Faulted and shattered rocks. 1901.
2944	(41) Top of north descent into Anstie's Cove, Torquay.	Crushed Devonian Limestone. "
2945	(32) North of Petit Tor, Torquay	Rock-fall from New Red Sandstone. "
2946	(33) " " "	" " " "
2947	(35) Hound Tor Ridge, near Lustleigh, Dartmoor.	Cleavage in Culm Grits and Slates. "
2948	(46) Near Lustleigh, Dartmoor	Hollows in Granite. "
2949	(47) Near Foxworthy, Dartmoor	Weathered surface of Granite. "

DORSET.—*Photographed by* Professor S. H. REYNOLDS, *M.A., F.G.S., University College, Bristol.* 1/4 *and* 1/2.

2950	(49) Stonebarrow Hill . .	Lower Lias. 1900.
2951	(48) Black Ven, from the east .	Lower Lias capped by Gault and Upper Greensand. 1900.

DURHAM.—*Photographed by* A. BINNS *and* M. DAWSON, *of Sunderland, and contributed by* *D. WOOLACOTT, *the University of Durham Philosophical Society.* 1/2.

2952	(18) Parson's Rock, Roker, near Sunderland.	'Cannon-ball' concretions in Magnesian Limestone. 1896.
2953	(21) Fulwell Quarries, near Sunderland.	Concretionary Magnesian Limestone. 1898.
2954	(22) Fulwell Quarries, near Sunderland.	Raised Beach. 1898.
2955	(23) Fulwell Quarries, near Sunderland.	" detail. "
2956	(19) Holey Rock, near Sunderland.	Caves in Upper Magnesian Limestone. 1898.
2957	(20) Hendon Banks, near Sunderland.	Lower Boulder Clay. 1896.

ESSEX.—*Photographed by* HORACE W. MONCKTON, *F.G.S., Harcourt Buildings, Temple, E.C.* 1/1 E.

3053	(1537) Grays Thurrock . .	Pleistocene Brick-earth. 1901.
3054	(1538) " " . .	" " "
3055	(1539) Sockett's Heath, north of Little Thurrock.	Plateau Gravels. "

GLOUCESTER.—*Photographed by* Professor S. H. REYNOLDS, *M.A., F.G.S., University College, Bristol.* 1/2 *and* 1/4.

2958	(68) Redland, Bristol . .	Small slips above excavation on Hill-slope. 1900.

Regd. No.		
2959	(69) Brislington Cutting, Bristol	Keuper resting unconformably on Pennant Grit. 1899.
2960	(70) Chipping Sodbury . .	Highly inclined Upper Limestone Shales. 1901.
2961	(83) Railway Cutting, Chipping Sodbury.	Lower Lias, White Lias, and Rhætic. 1901.
2962	(84) Railway Cutting, Chipping Sodbury.	„ „ with thin Limestones. „
2963	(85) Railway Cutting, Chipping Sodbury.	„ „ White Lias, and Rhætic. „
2964	(86) Railway Cutting, Chipping Sodbury.	„ „ 'Sun-bed,' Cotham Marble Rhætic. 1901.
2965	(87) Railway Cutting, Chipping Sodbury.	Rhætic resting unconformably on Carboniferous Limestone. 1901.
2966	(88) Lilliput Cutting, Chipping Sodbury.	Trias resting unconformably on Upper Limestone Shales. 1901.
2967	(89) Lilliput Cutting, Chipping Sodbury.	Upper Limestone Shales and discordant Upper Keuper. 1901.
2968	(82) South-east of Yate . .	Celestine *in situ*. 1901.
2969	(81) „ „ . . .	Blocks of Celestine Crystals. 1901.
2970	(71) Leckhampton Quarry, Cotswolds.	Inferior Oolite. 1901.
2971	(80) Leckhampton Quarry, Cotswolds.	Current-bedding in the Cephalopoda Bed. 1901.
2972	(72) Leckhampton Quarry, Cotswolds.	'Pea Grit' resting on Cephalopoda Bed. 1901.
2973	(74) Leckhampton Quarry, Cotswolds.	Weathered surface of Pea Grit. 1901.
2974	(73) Leckhampton Quarry, Cotswolds.	Oolitic Marl of Inferior Oolite. „
2975	(79) Leckhampton Quarry, Cotswolds.	Ragstone Series and Upper Freestones at base. 1901.
2976	(78) Cleeve Hill, Cheltenham .	Cephalopoda Bed, Pea Grit, and Lower Freestone. 1901.
2977	(76) „ „ .	Current-bedding in Cephalopoda Bed. 1901.
2978	(75) „ „ .	Freshly broken surface of Pea Grit. 1901.
2979	(77) „ „ .	Two small faults in Inferior Oolite. „

Photographed by C. H. Topham, 110 *York Road, Montpelier, Bristol.* 1/4.

3257	( ) Aust Cliff, R. Severn .	Rhætic Strata.	1901.
3258	( ) „ „ .	Fault in Rhætic Rocks.	„
3259	( ) „ „ .	Keuper.	„
3260	( ) „ „ .	Gypsum, and weathering of Keuper.	„
3261	( ) „ „ .	Gypsum in Keuper.	„

Hampshire (Isle of Wight).—*Photographed by* W. J. Harrison, *F.G.S., 52 Claremont Road, Handsworth.* 1/2.

2980	( ) Alum Bay	Chalk and Eocene Beds. 1902.
2981	( ) „	Eocene Sands. 1902.
2982	( ) „	„ „
2983	( ) Freshwater . . .	Chalk and Flints. 1902.
2984	( ) „	„ „ „
2985	( ) „ Bay . .	Chalk. 1902.
2986	( ) Compton Bay . . .	Wealden Beds. 1902.
2987	( ) Blackgang Chine . .	Lower Greensand. 1902.
2988	( ) „ „ . . .	„ „
2989	( ) Niton	Upper Greensand, cherty. 1902.

Regd. No.		
2990	( ) Niton Undercliff . .	Upper Greensand, cherty. 1902.
2991	( ) Luccombe Chine . .	Lower Greensand. 1902.
2992	( ) " " . .	" "
2993	( ) N. of Shanklin . .	" "
2994	( ) Stair Point, nr. Shanklin .	" "
2995	( ) S. of Sandown . . .	Wealden Beds. 1902.
2996	( ) "	" "

KENT.—*Photographed by* HORACE W. MONCKTON, *F.G.S., Harcourt Buildings, Temple, E.C.* 1/4 *and* 1/1 *E.*

2997	(1570) Railway Cutting, Orpington.	Woolwich Beds. 1901.
2998	(1568) S.E. Railway, between Chislehurst and Orpington.	" "
2999	(1571) "	" "

Photographed by E. PIERCE, *Balfour Road, South Norwood, and sent through the Croydon Scientific and Natural History Society.* 1/2.

3000	(7) Elmsmead, Sundridge Park, near Chislehurst.	Blackheath or Oldhaven Beds. 1901.
3001	(8) " "	" " "

Photographed by J. H BALDOCK, *St. Leonard's Road, Croydon, and sent through the Croydon Scientific and Natural History Society.* 1/2.

3002	(9) Elmsmead, Sundridge Park, near Chislehurst.	Blackheath or Oldhaven Beds. 1901.
3003	(10) " "	" " "

LANCASHIRE.—*Photographed by* *R. WELCH, *Lonsdale Street, Belfast.* 1/1.

3262	(R. W.) The Owens College Boulder, Manchester.	Block of Lake District Andesite dug up in Oxford Road. 1902.

LEICESTERSHIRE—*Photographed by* W. J. HARRISON, *F.G.S., 52 Claremont Road, Handsworth, Birmingham.* 1/2.

3004	( ) Church Quarry, Woodhouse Eaves, Charnwood Forest.	Brand Conglomerate, 'Little Slate,' and 'Trachose Grit.' 1902.
3005	( ) Looking S. from Woodhouse Windmill.	Triassic mantle over Archæan Rocks. 1902.
3006	( ) Woodhouse Windmill .	Woodhouse Beds. 1902.
3007	( ) Hanging Rocks, Woodhouse Eaves.	Lower Woodhouse Beds. 1902.
3008	( ) " "	Woodhouse Hornstones. 1902.
3009	( ) " "	Woodhouse Beds, above Slate-agglomerate. 1902.
3010	( ) " "	Slate-agglomerate and Beds above it. 1902.
3011	( ) " "	Jointing of Woodhouse Hornstones. 1902.
3012	( ) " "	Banded Woodhouse Hornstones. 1902.
3013	( ) " "	Lower Woodhouse Hornstones. 1902.
3014	( ) Beacon Hill, W. end, looking N.	Beacon Hill Hornstones. 1902.
3015	( ) Beacon Hill, centre of ridge, looking S.	" " "

Regd. No.		
3016	( ) Beacon Hill, looking E. along top.	Beacon Hill Hornstones. 1902.
3017	( ) Beacon Hill, centre of ridge looking S.	" " "
3018	( ) Beacon Hill . . .	Looking towards Broombriggs. 1902.
3019	( ) Broombriggs . . .	Beacon Hill Hornstones. 1902.
3020	( ) "	" " "
3021	( ) Altar Stones, Markfield .	Beds near Slate-agglomerate. 1902.
3022	( ) " "	Slate-agglomerate. 1902.
3023	( ) Rice Rocks, near Bardon	Woodhouse Beds. 1902.
3024	( ) " "	" "
3025	( ) " "	" "
3026	( )	
3027	( ) Warren Hills (W.) . .	Agglomerates. "
3028	( ) " . .	Slate-agglomerate and Hornstones. 1902.
3029	( ) " . .	" " " "
3030	( ) Peldar Tor, near Coalville.	Cleaved 'Porphyroid.' 1902.

Photographed by A. K. Coomáraswámy, *B.Sc., F.G.S., Walden, Worplesdon, Guildford.* 1/4.

3031	( ) Hanging Rocks, Woodhouse Eaves.	Trias mantling the features of the ancient rocks. 1902.
3032	( ) Charnwood Lodge Drive.	Agglomerate at right angles to cleavage. 1902.
3033	( ) " " "	Agglomerate parallel to cleavage. 1902.
3034	( ) High Sharpley . . .	Cleaved Porphyroid. 1902.
3035	( ) Mountsorrel Quarry . .	Keuper Marl resting on rounded granite surface. 1902.
3036	( ) " "	Terraced granite under Keuper Marl. 1902.

Photographed by P. H. Levi, *The Driffold, Sutton Coldfield.* 7/2.

3037	( ) Charnwood Lodge Drive.	Cleaved Agglomerate. 1902.
3038	( ) " " "	Agglomerate. 1902.
3039	( ) High Sharpley . . .	Cleaved 'Porphyroid.' 1902.
3040	( ) Mountsorrel Quarry . .	Terraced granite under Keuper Marl. 1902.
3041	( ) " " . .	" " " "
3042	( ) Swithland Reservoir, Buddon Wood.	Granite boss. 1902.

Leicester.—*Photographed by* *P. W. Wright, *Quorn, and presented by* Dr. Meadows, 33 *London Road, Leicester.* 1/2.

3043	( ) Mountsorrel Quarry . .	Terraced Granite under Keuper Marl. 1902.
3044	( ) " " . .	" " " "

Photographed by G. Hodson, *Loughborough.* 10/8.

3045	( ) Blackbrook, near Shepshed	Foundations of Masonry Dam, looking W. 1902.
3046	( ) Blackbrook, near Shepshed.	Foundations of Masonry Dam, looking W. 1902.
3047	( ) Blackbrook, near Shepshed.	Foundations of Masonry Dam, looking E. 1902.
3048	( ) Blackbrook, near Shepshed.	Foundations of Masonry Dam, looking E. 1902.

MIDDLESEX.—*Photographed by* HORACE W. MONCKTON, *F.G.S.*, *Harcourt Buildings, Temple, E.C.* 1/1 E.

Regd. No.		
3049	(1532) Tottenham Marsh, near Higham Hill.	Stratified Valley Gravel and Sand. 1901.
3050	(1528) Tottenham Marsh, near Higham Hill.	Alluvium of River Lea. 1901.
3051	(1530) Tottenham Marsh, near Higham Hill.	„ „ „
3052	(1531) Tottenham Marsh, near Higham Hill.	Stratified alluvium with shell-marl. 1901.

SHROPSHIRE.—*Photographed by* W. G. FEARNSIDES, *B.A., F.G.S.*, *Sidney Sussex College, Cambridge.* 1/4.

3071	(9) Mytton Dingle, Stiper Stones.	Lower Arenig Rocks. 1902.
3072	(4) Shelve Church . . .	Fossiliferous Lower Arenig Beds. 1902.
3073	(7) Tasgar Quarry, near Shelve.	Fossiliferous Upper Arenig Ashes. „
3074	(1) Meadowtown, near Minsterley.	Llandeilo Beds with *Ogygia*. 1902.
3075	(3) Between Chirbury and Priestweston.	Hagley (Bala) Ash, with 'ripplemarks.' 1902.
3076	(13) Shineton Brook. . .	Fossiliferous Tremadoc Rocks. 1902.
3077	(10) Carding Mill Glen, Church Stretton.	Longmyndian Valley. 1902.

SOMERSET.—*Photographed by* Professor S. H. REYNOLDS, *M.A., F.G.S.*, *University College, Bristol.* 1/4 *and* 1/2.

3078	(50) Below Beach Hotel, Portishead.	Ripple-marks in Old Red Sandstone. 1899.
3079	(51) Below Beach Hotel, Portishead.	Thin-bedded Old Red Sandstone. „
3080	(52) Vallis Vale, Frome . .	Infilling in Carboniferous Limestone. 1900.
3081	(53) „ „ . .	Unconformity, Inferior Oolite on Carboniferous Limestone. 1900.
3082	(54) „ „ . .	Unconformity, Inferior Oolite on Carboniferous Limestone. 1900.
3083	(55) „ „ . .	Unconformity, Inferior Oolite on Carboniferous Limestone. 1900.
3084	(56) „ „ . .	Unconformity, Inferior Oolite on Carboniferous Limestone. 1900.
3085	(57) Spring Cove, Weston-super-Mare.	Raised Beach on Carboniferous Rocks. 1901.
3086	(58) Spring Cove, Weston-super-Mare.	Flow of Basalt overlain by Carboniferous Limestone. 1901.
3087	(59) Spring Cove, Weston-super-Mare.	Lava resting on Carboniferous Limestone. 1901.
3088	(60) Middle Hope or Woodspring.	Carboniferous Limestone and associated Volcanic Rocks 1900.
3089	(61) „ „	Calcite veining Carboniferous lava. 1900.
3090	(62) „ „	Remains of Raised Beach adhering to cliff of Carboniferous Limestone. 1900.
3091	(63) Uphill Quarry, near Weston.	Cavities in Carboniferous Limestone filled with cave-earth. 1901.
3092	(64) „ „	Cavities in Carboniferous Limestone filled with cave-earth. 1901.
3093	(65) „ „	Cavities in Carboniferous Limestone filled with cave-earth. 1901.
3094	(66) „ „	Cavities in Carboniferous Limestone filled with cave-earth. 1901.
3095	(67) „ „	Cavities in Carboniferous Limestone filled with cave-earth. 1901.

SOMERSET.—*Photographed by* C. H. TOPHAM, 110 *York Road, Montpelier, Bristol.* 1/4.

Regd. No.			
3263	( )	Burrington Combe, Mendips.	Carboniferous Limestone Valley. 1902.

STAFFORDSHIRE.—*Photographed by* G. T. ATCHISON, *B.A., LL.B., Holmwood, Sutton Coldfield.* 1/2.

3246	(26)	Hints, near Tamworth .	False-bedding in Bunter Pebble-beds. 1902.
3247	(27)	" "	" " " "

SUFFOLK.—*Photographed by* W. J. HARRISON, *F.G.S.,* 52 *Claremont Road, Handsworth, Birmingham.* 1/2.

3056	( )	Pakefield	Westleton Beds. 1902.
3057	( )	"	" "
3058	( )	"	Mid-Glacial Loams and Sands. 1902.
3059	( )	"	" Sands. 1902.
3060	( )	"	" " "
3061	( )	"	" " "
3062	( )	"	" " "
3063	( )	Kessingland . . .	" " "
3064	( )	"	Chalky Boulder-clay above Mid-Glacial Sands. 1902.
3065	( )	Corton	Sun-cracks on Boulder-clay. 1902.
3066	( )	"	Forest Bed below Glacial Sands. 1902.

SURREY.—*Photographed by* J. H. BALDOCK, *St. Leonard's Road, Croydon.* 1/2.

3067	( )	Railway Cutting, Thornton Heath.	Eroded surface of Oldhaven Beds covered by London clay. 1902.
3068	( )	Railway Cutting, Thornton Heath.	Eroded surface of Oldhaven Beds covered by London clay. 1902.

Photographed by HORACE W. MONCKTON, *F.G.S., Harcourt Buildings, Temple, E.C.* 1/4.

3069	(223)	Pits near Caterham Waterworks.	Oldhaven Pebble Beds. 1894.
3070	(220)	Pits near Caterham Waterworks.	" " "

WARWICKSHIRE.—*Photographed by* A. K. COOMÁRASWÁMY, *B.Sc., F.G.S., Walden, Worplesdon, Guildford.* 1/4.

3096	( )	Tuttle Hill Quarries, Nuneaton.	Cambrian Quartzite and Camptonite Sills. 1902.

WESTMORLAND.—*Photographed by* GODFREY BINGLEY, *Thorniehurst, Headingley, Leeds.* 1/2.

3097	(5621)	Dunmail Raise . .	Moraines. 1901.
3098	(5667)	Grasmere	Delta. "
3099	(5581)	Blindtarn Moss, Grasmere.	" "
3100	(5582)	Easdale from near foot of Tarn.	*Roche moutonnée.* 1901.
3101	(5585)	Easdale Tarn, near Grasmere.	Boulder and Moraines. 1901.

Regd. No.		
3102	(5586) Easdale Tarn, near Grasmere	Moraines. 1901.
3103	(5588) Easdale Tarn, near Grasmere.	Delta. „
3104	(5590) Easdale Tarn, near Grasmere.	Moraines at foot of Tarn. 1901.
3105	(5657) Greenburn Bottom, near Grasmere.	Moraines. 1901.
3106	(5658) Greenburn Bottom, near Grasmere.	„ „
3107	(5659) Greenburn Bottom, near Grasmere.	„ „
3108	(5660) Greenburn Bottom, near Grasmere.	„ „
3109	(5573) Rydal Water . . .	Delta. „
3110	(5617) View from Fairfield .	Grasmere, Elter Water, and Coniston. 1901.
3111	(5616) From Fairfield . .	Rydal and Windermere. 1901.
3112	(5599) Grisedale Tarn . .	St. Sunday Crag and Ulleswater. 1901.

WORCESTERSHIRE.—*Photographed by* W. J. HARRISON, *F.G.S., 52 Claremont Road, Handsworth, Birmingham.* 1/2.

3113	( ) The Lickey Hills, from Rubery Hill.	Cambrian Quartzite. 1902.
3114	( ) The Lickey Hills . .	Manganese in Quartzite. 1902.
3115	( ) Rubery Hill, The Lickey .	Fault in Quartzite. 1902.
3116	( ) Rubery	Junction of Cambrian Quartzite with Llandovery Sandstone. 1902.
3117	( ) Beacon Hill, The Lickey .	Permian Breccia. 1902.
3118	( ) „ „	„ „ „

Photographed by *NORMAN KING, *Malvern, and presented by* A. K. COOMÁRASWÁMY, *B.Sc., F.G.S.* 14/10.

3119	( ) Looking south from Worcester Beacon.	Malvernian summits in cloud.

YORKSHIRE.—*Photographed by* HORACE W. MONCKTON, *F.G.S., Harcourt Buildings, Temple, E.C.* 1/4.

3120	(1490) Cliff south of Filey .	Twisted and slipped Boulder-clay. 1900.
3121	(1550) Osgodby Nab and Carnelian Bay, Scarborough.	Nab, and landslip. 1901.
3122	(1552) Osgodby Nab and Carnelian Bay, Scarborough.	Landslip, from Nab. „
3123	(1553) Osgodby Nab and Carnelian Bay, Scarborough.	„ Boulder-clay. 1901.

Photographed by GODFREY BINGLEY, *Thorniehurst, Headingley, Leeds* 1/2 *and* 1/4.

3124	(5857) The Peak . . .	Estuarine Beds, Dogger, and Lias. 1902.
3125	(5903) Blea Wyke Point, Peak .	Estuarine Beds, Dogger, and Blea Wyke Beds. 1902.
3126	(5899) The Peak, N. from Beach	Lower Estuarine Beds and Dogger. 1902.
3127	(5901) „ looking towards Robin Hood's Bay.	„ „ „ Dogger, and Blea Wyke Beds. 1902.
3128	(5858) The Peak, on the line of fault.	Upper Lias thrown against Dogger and Estuarine Beds. 1902.
3129	(5897) The Peak, Undercliff .	Lower Estuarine Series. 1902.

Regd. No.		
3130	(5882) Cliffs near Coastguard Station, Whitby.	Boulder-clay banked against Estuarine Sandstone. 1902.
3131	(5796) From Cliffs near Whitby Abbey to Saltwick Nab.	Upper Lias capped by Dogger and Boulder-clay. 1902.
3132	(5797) Saltwick Nab and Whitby	Upper Lias and Dogger capped by Boulder-clay. 1902.
3133	(5798) Black Nab, Saltwick .	Upper Lias and Dogger. 1902.
3134	(5800) „ „	„ „ „
3135	(5801) Saltwick. . . .	„ „ „
3136	(5802) „ . . .	„ „ „
3137	(5863) Sandsend Ness towards Whitby.	Upper Lias Shale. „
3138	(5864) Cliffs S. of Kettleness, northwards.	Oolite and Upper Lias. „
3139	(5865) Cliffs S. of Kettleness, southwards.	„ „ „
3140	(5867) Kettleness . . .	Old alum workings. „
3141	(5868) Cliffs near Runswick .	Middle Lias Shales. „
3142	(5877) Staithes Nab, or Colborne Nab.	„ resting on Lower Lias. 1902.
3143	(5879) Old Nab, Staithes . .	Upper Lias. 1902.
3144	(5812) Moors between Goathland and Egton Bridge.	Notches of Moss Swang Overflow and Castle Rigg Oxbow. 1902.
3145	(5813) Moors between Goathland and Egton Bridge.	Gorge of Wheeldale Beck (Murk Esk). 1902.
3146	(5815) Scar Wood, near Goathland.	Wheeldale Beck (Murk Esk). 1902.
3147	(5816) Scar Wood, near Goathland.	„ „ „
3148	(5819) Moors between Goathland and Egton Bridge.	Randay Mere Overflow. 1902.
3149	(5822) Moors between Goathland and Egton Bridge.	„ „ „
3150	(5820) Moors between Goathland and Egton Bridge.	Purse Moor Slack, near Intake. 1902
3151	(5823) Moors between Goathland and Egton Bridge.	Moss Swang, looking to Intake from Castle Hill. 1902.
3152	(5826) Moors between Goathland and Egton Bridge.	Moss Swang, looking up towards Intake. 1902.
3153	(5827) Moors between Goathland and Egton Bridge.	Intake of Castle Hill Oxbow from Moss Swang. 1902.
3154	(5828) Moors between Goathland and Egton Bridge.	Moss Swang, downstream from near Intake. 1902.
3155	(5829) Moors, North of Danby .	Ewe Cragg Beck. 1902.
3156	(5830) „ „	„ upstream. 1902.
3157	(5832) „ „	„ downstream. „
3158	(5833) „ „	Intake of Ewe Cragg Slack at swampy watershed. 1902.
3159	(5834) „ „	Hardale Slack, Roxby Moor, downstream. 1902.
3160	(5835) „ „	Hardale Slack, with deserted Oxbow. 1902.
3161	(5836) Lealholme, near Danby .	Crunkley Gorge, a diversion of the Esk by Moraine Ridges. 1902.
3162	(5840) Fylingdale Moors . .	Intake of great Overflow Channel near Foul Sike. 1902.
3163	(5841) „ „	Foul Sike Channel, downstream. 1902.
3164	(5842) „ „	„ „ upstream. „
3165	(5843) „ „	Biller Howe Dale, Overflow of Iburndale Lake, upstream. 1902.
3166	(5844) „ „	Biller Howe Dale, across Intake of small Biller Howe Slack. 1902.

Regd. No.		
3167	(5845) Fylingdale Moors . .	Biller Howe Dale, below confluence with Foul Sike Valley. 1902.
3168	(5847) ,, ,, . .	Brown Rigg, deserted High-level Channel. 1902.
3169	(5849) ,, ,, . .	Cloughton Moor Cottage, Overflow Channel, 1902.
3170	(5850) Harwood Moor, Fylingdale Moors.	Peat Cutting. 1902.
3171	(5851) ,, ,, .	,, ,,
3172	(5852) Seamer Moor, Scarborough.	Moraine. ,,
3173	(5853) Hagworm Hill, Seamer Moor.	,, ,,
3174	(5854) Forge Valley, near Scarborough.	Diversion of River Derwent.
3175	(5855) Throxenby Mere, near Scarborough.	Partially artificial pool in Overflow Channel, 1902.
3176	(5856) North of Throxenby Mere	Small dry Overflow Channel. 1902.
3250	(6055) Gannister Quarry, Meanwood Valley, Leeds.	Fossil Tree in Coal-measures. ,,
3251	(6057) Gannister Quarry, Meanwood Valley, Leeds.	Roots in Coal-measures. 1902.
3252	(6058) Gannister Quarry, Meanwood Valley, Leeds.	Gannister, showing Fossil Fern. 1902.
3253	(5924) Whinskill, near Settle .	Perched Boulder (Silurian) on Carboniferous Limestone. 1902.
3254	(5925) ,, ,,	Perched Boulder (Silurian) on Carboniferous Limestone. 1902.
3182	(5907) 'Heading,' Garforth Colliery Sandpit.	Magnesian Limestone and 'Quicksand' resting unconformably on Coal-measure Shales. 1902.
3183	(5908) Garforth, near Leeds .	Magnesian Limestone resting on 'Quicksand.' 1902.
3184	(5910) Hope Hill Quarry, Kippax	Lower Magnesian Limestone. 1902.
3185	(5911) Town Hill Close, Kippax	Magnesian Limestone resting on current-bedded Sands. 1902.
3186	(5912) ,, ,, ,,	Lower Magnesian Limestone, with crack and subsoil. 1902.
3187	(5924) Quarry near Saxton and Barkston.	Magnesian Limestone. 1902.
3188	(5925) Quarry near Saxton and Barkston.	,, ,, ,,
3189	(5785) Ashfield Brickworks, Conisborough.	Lower Permian Marls contorted and faulted. 1901.
3190	(5786) Ashfield Brickworks, Conisborough.	Lower Magnesian Limestone Escarpment. 1901.
3191	(5787) Ashfield Brickworks, Conisborough.	Lower Magnesian Limestone, Clays, Marls, and Sandy Limestone resting on Coal-measures. 1901.
3192	(5788) Near Conisborough .	Weathered Block of Magnesian Limestone. 1901.
3193	(5789) ,, ,, .	Ridge of weathered Magnesian Limestone. 1901.
3194	(5791) Warmsworth, near Doncaster.	Lower Magnesian Limestone. 1901.
3195	(5792) Balby, near Doncaster .	Bunter Sands. 1901.
3196	(5793) ,, ,, .	,, ,, False Bedding. 1901.
3197	(5568) Rishworth Moor, Blackstone Edge.	Peat, about 4 feet thick. 1901.

Photographed by W. J. FORREST, 13 *Arlington Street, Bradford* 1/4.

Regd. No.			
3198	( )	Green Lane Schools, Bradford.	Fault in 'Better Bed' Coal. 1902.
3199	( )	„ „ „	„ „ „

Photographed by A. H. ROBINSON, *Troutsdale, Hackness, Scalby.* 1/2.

3177	( )	Lockton, North Riding .	The Bridestones. 1902.
3178	( )	„ „	„ „
3179	( )	„ „	„ „
3180	( )	„ „	„ „
3181	( )	„ „	„ „

Photographed by C. J. WATSON, *Bottville Road, Acocks Green.* 1/4.

3264	(1642)	Lister Park, Bradford .	Carboniferous Tree and Roots. 1900.
3265	(1644)	Clayton, Bradford . .	Stigmaria *in situ*. 1900.
3266	(1646)	Horton Park, Bradford .	Carboniferous Tree-roots. 1900.

WALES.

GLAMORGAN.—*Photographed by* A. K. COOMÁRASWÁMY, *B.Sc., F.G.S. Walden, Worplesdon, Guildford.* 1/4.

3200	( )	Near Bishopston, Gower .	Dry Valley and Swallow-hole in Carboniferous Limestone. 1902.
3201	( )	„ „ „	'Daw-pit' or Swallow-hole in Carboniferous Limestone. 1902.
3202	( )	Tuit Hill, from Mumbles Head, Gower.	Carboniferous Limestone, with changing strike. 1902.
3203	( )	Mumbles Head, Gower .	Carboniferous Limestone. 1902.
3204	( )	„ „ West End	„ „ steep dip and nodular masses. 1902.
3205	( )	Mumbles Hill . . .	Lenticle of Shale in Carboniferous Limestone. 1902.
3206	( )	Mewslade Bay, Gower .	Fossiliferous Carboniferous Limestone. 1902.
3207	( )	„ „ „ .	'Head' over (Blown sand) Loam, Raised Beach, and Carboniferous Limestone. 1902.
3208	( )	„ „ „ .	Carboniferous Limestone Cliffs. 1902.
3209	( )	„ „ „ .	„ „ „ „
3210	( )	„ „ „ .	Carboniferous Limestone, Rhosilly Down (Old Red Sandstone) behind. 1902.
3211	( )	„ „ „ .	Carboniferous Limestone Cliffs. 1902.
3212	( )	Bacon Hole, Gower . .	'Head' at mouth of Cave. 1902.
3213	( )	„ „ looking in .	„ „ „ „
3214	( )	„ „ „ out .	Roof of Cave, Stalagmite, and 'Head' below it. 1902.
3215	( )	E. of Pwll Du Bay, Gower	Raised Beach with Shells on Carboniferous Limestone. 1902.
3216	( )	„ „ „	Raised Beach with Shells on Carboniferous Limestone. 1902.
3217	( )	Near Penard Castle, Gower	Old Red Conglomerate. 1902.
3218	( )	Penard Pill, Three Cliff Bay, Gower.	Thrust-fault in Carboniferous Limestone. 1902
3219	( )	Approach to Three Cliff Bay.	Fault-arch. 1902.
3220	( )	Three Cliff Bay, Gower .	Raised Beach Platform, with 'Head' and Raised Beach. 1902.
3221	( )	„ „ „ „ .	Angular 'Head' on Raised Beach Platform. 1902.

Photographed by Professor S. H. Reynolds, *M.A.*, *F.G.S.*, *University College, Bristol.* 1/4.

Regd No.		
3222	(1) Penarth Head	Bands of Gypsum in Keuper. 1901.
3223	(2) „ „	„ „ „ „
3224	(3) Between Penarth and Lavernock Point.	Lower Lias to Tea-green Marls. 1901.
3225	(4) Between Penarth and Lavernock Point.	Lower Lias to Tea-green Marls. 1901.
3226	(5) Between Penarth and Lavernock Point.	Fault in Trias. 1901.
3227	(6) Lavernock Point	Lower Lias and Rhætic Shale. 1901.
3228	(7) „ „	„ „ „

Montgomery.—*Photographed by* W. G. Fearnsides, *B.A.*, *F.G.S.*, *Sidney Sussex College, Cambridge.* 1/4.

3229	(6) Corndon, from Marsh Pool	Laccolite of Dolerite. 1902.

SCOTLAND.

Banffshire.—*Photographed by* A. S. Reid, *M.A.*, *F.G.S.*, *Trinity College, Glenalmond, Perthshire.* 1/2.

3239	(T.R. 14) Fiddes Fort, Troup Estate.	Joints in Old Red Sandstone Conglomerate. 1900.
3240	(T.R. 55) Cullican Beach, Fiddes Fort, Troup.	Joints in Old Red Sandstone Conglomerate. Close view. 1900.
3241	(T.R. 56) „ „ „	Same joint as 3240, looking out to sea. 1900.
3242	(T.R. 57) 'Devil's Kitchen,' Fiddes Fort, Promontory, Troup.	W. side of joint cave pierced through promontory. 1900.
3243	(T.R. 1) 'Needle's Eye,' Fiddes Fort, Promontory.	Interior of 3242. 1900.
3244	(T.R. 24) 'Hell's Lum, Troup	Blow-hole broken in along master-joints. 1900.
3245	(T.R. 23) Gardenstown	Promontory cut off to form stack. 1900.

Lanarkshire.—*Photographed by* C. J. Watson, *Bottville Road, Acocks Green, Birmingham.* 1/4.

3230	(1695) Partick	Fossil Tree in Coal-measures. 1901.
3231	(1696) „	Coal-measure Forest. 1901.

Photographed by J. Barrowman, *Staneacre, Hamilton, N.B.* 1/2.

3232	( ) Chatelherault Park, near Hamilton.	Bedding and dislocation in Sands above the Coal-measures. 1902.
3233	( ) Chatelherault Park, near Hamilton.	Bedding and dislocation in Sands above the Coal-measures. 1902.

Perthshire.—*Photographed by* A. S. Reid, *M.A.*, *F.G.S.*, *Trinity College, Glenalmond, Perth.* 1/2.

3248	(A.F. 4) Runnagour, Aberfoyle	*Roche moutonnée.* 1902.
3249	(A.F. 15) „ „	„ „ „

SHETLAND.—*Photographed by* W. H. BEEBY, *Hildasay, Thames Ditton.* 5/4.

Regd. No.		
3234	( ) Noup of Noss . . .	Old Red Sandstone. 1899.
3235	( ) „ „ . . .	„ „ „ „

IRELAND.

ANTRIM.—*Photographed by* A. T. METCALFE, *F.G.S., Southwell, Notts.* 1/2.

3236	(G.A. 20) Tieveragh Hill, Cushendall (distant view).	Tertiary Volcanic 'Neck.' 1901.
3237	(G.A. 19) Tieveragh Hill, Cushendall (near view).	„ „ „ „
3238	(G.A. 3) Portrush . . .	Segregation veins in a Dolerite sill. 1901.

Photographed by Miss M. K. ANDREWS, 12 *College Gardens, Belfast.* 1/4.

3267	(71) Whitewell Quarry, Belfast	Chalk traversed by Basalt Dyke. 1902.

Photographed by *R. WELCH, *Lonsdale Street, Belfast.* 1/1.

3268	(R.W. 386B) Gobbins Cliffs, Islandmagee.	'Man-o'-War' Sea Stack, resulting from weathering of dyke. 1902.
3269	(R.W. 386) Gobbins Cliffs, Islandmagee.	Basalt. 1902.
3270	(R.W. 5166) Gobbins Cliffs, Islandmagee.	Basalt-flows, highly vesicular in upper parts. 1902.
3271	(R.W. 5168) Gobbins Cliffs, Islandmagee.	Honeycombing in amygdaloidal basalt. 1902.
3272	(R.W. 5218) Cloughan Point .	Raised Beach, general character at highest point. 1902.
3273	(R.W. 5217) „ „ .	Raised Beach on tilted Trias. 1902.
3274	(R.W. 5216) „ „ .	„ „ near view „
3275	(R.W. 5219) Cloughan Harbour	Chalk covered with Consolidated Gravels and Boulder-clay. 1902.
3276	(R.W. 5206) Falls Road, Belfast	Trias Sands overlain by Boulder-clay. 1902.

DONEGAL.—*Photographed by* *R. WELCH, *Lonsdale Street, Belfast.* 1/1.

3277	(R.W. 5223) Rosguill Peninsula, Rosapenna.	Granite, intrusive into Diorite. 1902.
3278	(R.W. 5215) Melmore Mt., and Kitchen Midden, near Rosapenna.	Junction, Granite and Schist. „
3279	(R.W. 2274) Remnant of Lord Boyne's House, Rosapenna	Overwhelmed by drifting sand. „
3280	(R.W. 2279) 'Eye of Rosguill,' Rosapenna.	Natural arch eroded in quartzites. „
3281	(R.W. 1484) Bunglass Cliff, Slieve Liag.	Marine and sub-aërial erosion. „

DOWN.—*Photographed by* *R. WELCH, *Lonsdale Street, Belfast.* 1/1.

3282	(R.W. 5213) Ballyhome . .	Raised Beach, Oxides of Iron and Magnesia cementing some of the coarser Gravels. 1902.
3283	(R.W. 5212) Belfast Lough .	Fossil-shells from Estuarine Clays. 1901.

DUBLIN.—*Photographed by* *R. WELCH, *Lonsdale Street, Belfast.* 1/1.

Regd. No.		
3284	(R.W. 5224) The Dingle, Carrickmines.	'Dry Gap' in massive granite. 1902.
3285	(R.W. 5226) Esker, Greenhills, Dublin.	Irregular Bedding. 1902.
3286	(R.W. 5227) Esker, Greenhills, Dublin.	Ripple-drift in fine sand of sand pit. 1902.
3287	(R.W. 5231) Puck's Rocks, Howth.	Slate and Quartzite crushed against Quartzite. 1902.
3288	(R.W. 5230) Sutton, Howth .	Boulder-clay resting on planed surface of Quartzite and Slate. 1902.
3289	(R.W. 5232) Near the Bailey, Howth.	Breccia of Quartzite and Slate cemented by Carbonate of Lime. 1902.

FERMANAGH.—*Photographed by* *R. WELCH, *Lonsdale Street, Belfast.* 1/1.

3290	(R.W. 5211) Gubbaroe Point, Lower Lough Erne	Water-worn Carboniferous Sandstone. 1900.

SLIGO.—*Photographed by* *R. WELCH, *Lonsdale Street, Belfast.* 1/1.

3291.	(R.W. 5210) Bog at Grange, near Sligo.	Peat, with Tree-roots *in situ*.

Kesh Caves, co. Sligo.—Report of the Committee, consisting of Dr. R. F. SCHARFF (*Chairman*), Mr. R. LL. PRAEGER (*Secretary*), Mr. G. COFFEY, Professor G. A. J. COLE, Professor D. J. CUNNINGHAM, Mr. G. W. LAMPLUGH, Mr. A. MCHENRY, *and* Mr. R. J. USSHER, *appointed to explore Irish Caves.* (*Drawn up by the Chairman.*)

THE Committee submitted to the Association a short interim report on the Sligo caves last year. The renewed grant received at Glasgow has enabled them to continue the excavations at Kesh, and to open several new caves near Ennis in county Clare.

The following report on the Kesh caves is in the main by Mr. R. J. Ussher, who has been in charge of the operations, and who has devoted many weeks with most painstaking industry to this work. Professor Cole and Mr. Lamplugh, the latter having joined the Committee since the Glasgow Meeting, have incorporated some interesting remarks on the geological aspects of the excavations, while Mr. G. Coffey has furnished the descriptions of the human implements found in the caves. I myself have undertaken the determination of the mammalian remains, and I have to acknowledge the very kind assistance of Dr. Forsyth Major and Mr. E. T. Newton in naming some of the more critical bones, while Professor Stewart and Mr. O. Thomas gave me every facility to consult the collections in their charge. Mr. E. T. Newton has undertaken the determination of the numerous bird remains, and Messrs. Kennard and Woodward are preparing a report on the land mollusca.

In the tabular statement at the end I have given a list of all the species of mammalia whose remains were discovered. The queries indicate that, although the species occurred in the layers marked, the fragmentary character of the remains was suggestive of their having accidentally dropped into that particular layer.

Kesh, or as it is locally spelled 'Keash,' is fifteen miles south of the town of Sligo, and consists of a few scattered buildings, with farms about them. The spot is at the foot of Keishcorran Mountain, an isolated mass of Carboniferous limestone which rises to 1,183 feet; and the country which extends south and west from this mountain for miles from Kesh presents an array of gravel eskers and elongated mounds of glacial material, with here and there a small lake or marsh in the hollows between them. Sprinklings of erratic boulders and stones occur up to the very summit of the mountain. These consist principally of red sandstone, with a few of yellow sandstone and of dyke rocks. It is believed that these rocks could be found in place on the next hill range to the S. and S.E. of Kesh, around Lough Key, but this point has not been definitely established. Though no continuous deposit of drift was seen on the mountain, these erratic blocks are sufficient to show that it has been overwhelmed by ice.

On approaching Keishcorran from Kesh one sees a grass-grown talus which extends up from the plain at a steep angle for several hundred feet. Surmounting this is a range of cliffs running along the mountain face like the gigantic walls of an ancient city. These are pierced along the top of the talus by a range of some thirteen caves. Towards the northern end of this series is a cavern whose large orifices, about 15 feet high, can be seen for miles. The other caves are of various sizes, but the type which prevails is that of a vertical fissure enlarged downwards into an 'A' shape. The cliff which they penetrate faces S.W., or S.W. by W., and their direction is approximately parallel. These caves are intersected at various distances from their mouths by cross fissures, which in several cases form connecting galleries from cave to cave. This feature is more or less common to them all. The whole system of excavations, in fact, clearly depends upon the jointed structure of the limestone. The great cliff is due to the flaking away of the mass along one series of vertical joints, and solution works along the same series within, and produces passages and fissures parallel to the face. The caves connected by these fissures have also been worked out by solution, acting along the second vertical series of joints which run in perpendicularly to the great cliff face. The general slope of the cave-floors is from within outwards, and the contained deposits are mainly the detritus and residue of the limestone rock, with fallen blocks from the walls and roof, set in a soft calcareous tufa.

Coffey Cave.

Our excavations were commenced in May 1901 at the mouth of one of the larger caves, which is about central in the series, and which we distinguish as the Coffey Cave. It has a lofty A-shaped mouth, and a large deposit of clay occupies its lower portion. The section made in this across the cave's mouth disclosed the following deposits in descending order:—

1. *Surface soil* of a blackish brown, containing charcoal, a tyne of Red Deer antler, the broken bones of domestic animals, and a few implements indicating temporary occupation by man rather than fixed settlement. The bones and implements are such as are commonly found in raths and crannogs, and the depth of this layer is from 6 to 12 inches.

2. *Breccia*, consisting of limestone blocks and fragments fallen from the roof, in a deposit of calcareous tufa. This bed contained numerous land shells (*Helix*, *Hyalinia*, *Clausilia*) and bones of small mammals.

Among these the Arctic Lemming was numerously represented as well as in the next stratum. This is the first instance in which this animal has been identified as a former inhabitant of Ireland. A mandible has been referred to the Irish Stoat, though smaller than that of a Weasel; and some canine remains have not yet been definitely identified. The depth of the breccia is from 1 foot in the centre increasing to 3 feet at the sides of the cave.

3. *Clay* of a brown ochreous colour containing large blocks of limestone and numerous bones of small mammals (including Lemming), as well as a few of larger ones. At a depth of 6 feet from the surface a large glaciated block of limestone was found.

Plunkett Cave.

Owing to the difficulty of removing the numerous limestone blocks we searched for more promising ground and decided to work at a smaller cave, one of the most southern of the series, which opened at a somewhat higher level. We called this the Plunkett Cave. A lofty entrance narrows down to a low mouth, from 5 to 6 feet wide, and inside this the cave becomes much more lofty and widens at a distance of from 12 to 16 feet from the mouth. It then forms a gallery 6 to 10 feet wide which pursues a generally straight course, terminating at 49 feet from the mouth. Before this termination is reached, however, a gallery branches off to the right, and this, after running some 20 feet, expands into a lofty hall, the Sloping Chamber, that has another branch to the left, parallel with the Plunkett Cave. We called this latter branch the Water Gallery.

At the commencement of the operations no part of these galleries was completely choked, but all contained a considerable depth of deposits, chiefly of earths and clays, with blocks and fragments of limestone.

The upper or surface stratum, which varied from 6 inches to 2 feet in depth, contained a large amount of calcareous tufa, and as we advanced into the inner galleries this tufa grew more and more free from earthy admixture, being in places as white as mortar. While a variable amount of calcium carbonate occurs in this deposit, its whiteness is in part due to the usual residue of siliceous particles that results from the removal of limestone in solution. Characteristic bipyramidal crystals of quartz are thus found in some parts; and in the Water Gallery a delicately spicular deposit occurs. A multitude of minute rods, sometimes set with knobs, are seen when the tufa is dissolved away in acetic acid. Dr. G. J. Hinde, F.R.S., who has kindly examined these for us, points out that they are crystalline and soluble in nitric acid. Their true character is still under consideration. In all parts of the cave explored by us this white stratum contained charcoal, sometimes in lumps and occasionally in horizontal layers, which formed distinct seams in our sections. In the most remote part excavated by us, the Water Gallery, there was a black layer of charcoal 1 inch deep, which extended from wall to wall, with a bed of white tufa above and beneath it, and at the bottom of the lower tufa there was more charcoal. Some pieces of peat were also found embedded elsewhere, which were probably brought into the cave for fuel.

In the lower part of the upper stratum a large stone celt was found 5 feet inside the cave's mouth, the only evidence of neolithic occupation, and not far from it was a portion of a small iron saw of peculiar make, resembling those found in Dunshaughlin crannog, and in the same vicinity a bronze pin with a ring attached to it. The upper stratum contained a second bronze pin at 38 feet from the mouth of the cave, and farther in again was a small iron rod. Shells of marine Mussels repeatedly occurred in this upper stratum and also an oyster-shell, though the sea is now fifteen miles distant, and is not likely to have been much nearer in neolithic times.

The human remains were few, and occurred chiefly near the Sloping Chamber; but the bones and teeth of domestic animals were exceedingly numerous, and were found wherever the stratum extended. These were generally fragmentary and represented the species usually found in Irish kitchen middens, viz., horse, red deer, ox, sheep, goat, pig, and dog.

Among the wild species represented in this upper stratum fox and rabbit were numerous, hare and red deer less so; but an interesting find was a metatarsus of reindeer, which occurred in the gallery to the right, deep down in this stratum; while charcoal was found lower down in the same deposit and in the same bench, each bench measuring 2 feet wide.

In several parts of the cave the upper stratum contained bones of brown bear. These were found near the lower horizon of the deposit, so that in some cases they may have been lying on the surface of the clay which formed the second stratum where the deposition of the upper one commenced. In one case a bone of a bear was partly embedded in the upper stratum and partly in the clay.

Bones of field-mice were numerous, as well as those of frog.

The *second stratum of clay*, which also extended throughout the galleries of the Plunkett Cave, was brown, inclining to ochreous, more or less sandy, and contained numerous fragments of limestone and chert. Worn rounded pebbles were scarce in the clay, and occurred chiefly in or near the Water Gallery.

The quartz sand in this yellowish clay seems to be truly detrital and of external origin; it sometimes largely predominates over the clayey particles. The clay itself, however, probably arises from the decay of certain layers of the limestone, since it contains, and at times abundantly, the typical bipyramidal crystals of quartz. Its non-calcareous nature shows that it was deposited when solution was fairly active, while the upper tufaceous deposits indicate conditions favourable to stalagmitic growth.

The presence of occasional worn pebbles of red sandstone in the interior of the caves might be explained on the supposition that the pebbles had been washed down pot holes and crevices from the hill above. The gravelly deposit at the mouth of the Plunkett Cave could not, however, be thus explained. It is too thick and too limited in area, and some of its contained boulders are too large to have been thus introduced, and there seems no escape from the conclusion that the gravel has been washed to the mouth of the cave from without.

Some of the larger limestone boulders, especially those towards the top of the gravel, were undoubtedly glaciated (not only scratched, but exhibiting also the characteristic shape of glaciated blocks), and did not seem to have been worn or washed much since this glaciation.

There is not enough drift on the mountain above to explain the presence of the gravel as a down-wash, even if the contour of the hill were such as to render a down-wash of this kind possible, which is not the case. The plain of drift, with its characteristic original moundy topography, lies considerably below the mouths of the caves, with a steep talus slope now separating them, and it is highly improbable that there has ever been a plateau of drift material so high as the mouths of the caves at any time since the disappearance of the ice. There seems, therefore, to be no other explanation possible for the gravel deposit than that it has been washed into the mouth of the cave at a time when the ice was at least as high as the escarpment into which the caves are cut, and that the mouth of the Plunkett Cave was already an open passage at that period.

Hence it becomes a point of much importance to determine whether the caves contain any deposits of older date than the glacial period, and this point deserves especial prominence in any future exploration. The yellow clay with chert, the lowest deposit discovered, is not a true 'boulder clay.' It seems to be such material as might be derived from the solution of the limestone mixed with sand and mud from the waters entering the cave from without. We were not satisfied that this clay was older than the gravel deposit. No fossils having as yet been found in the yellow clay, the question as to its relation to the glacial period is at present of geological interest only, and no palæontological point is involved.

If a fossiliferous deposit were discovered below the yellow clay it would be of much scientific interest. That pre-glacially filled fissures may occur in the Carboniferous limestones in this country is shown by the presence of an earth-filled fissure overlain by boulder clay in a limestone quarry at Howth, which one of us examined recently, but without noticing any fossils in it.

A block and cone of crystalline stalagmite were found in the clay in the Water Gallery, but these were the only examples noticed of this ancient form of stalagmite which had evidently been broken up in this cave.

The lower portion of the clay seemed to be devoid of bones as well as of any relics of man, but in the upper portion of this deposit we found animal remains, including a human tooth ; and a little charcoal was met with in four different spots. This strongly contrasted with the abundance of the latter material, which was everywhere present in the upper stratum ; and even these few traces of it must be mentioned with caution, as burrowing animals may have penetrated into the clay, and thus might have transmitted into it some bits of charcoal from the upper stratum. Remains of domestic animals, so abundant in the latter, were virtually absent from the clay, a bone or two of ox and of goat being all the relics in it assignable to those mammals. The pig was, however, represented in four places.

The characteristic animal throughout this stratum was the brown bear, whose bones and separated teeth numbered sixty at least, and occurred in all parts of the cave, becoming more frequent in the inner galleries. Fox was found in fourteen places, hare in seven, red deer in four, rabbit in three, wolf in at least one instance, and lemming once (at the entrance), while frog and field-mouse occurred repeatedly.

We sank deep sections in several parts of the cave, with the result that it was found to narrow downwards and was filled in that direction with barren clay, which became yellow and tenaceous as the rock was approached in our excavations. Near the cave's mouth large quantities of yellow clay were found, and it may be proper to treat it as a separate deposit distinct from the brown sandy clay. No drift stones have been noticed in the yellow clay.

It will be seen from this report that during the deposition of the upper strata the Plunkett Cave was inhabited for a long time by men who used domestic animals and marine molluscs, and had implements of iron, bronze, and polished stone, and who, in the earlier part of this period, were contemporaneous with the reindeer and probably with the bear.

In the subjacent clay there are evidences, left during a previous epoch, that bears then inhabited the cave undisturbed by human intrusion.

Tabular Statement of the Mammalian Remains (*Preliminary*).

—	Surface Stratum	Breccia	Clay
Pig (*Sus scrofa*)	×	—	×
Horse (*Equus caballus*)	×	—	—
Ass (*E. asinus*)	×	—	—
Red Deer (*Cervus elaphus*)	×	—	×
Reindeer (*Rangifer tarandus*)	×	—	—
Sheep (*Ovis aries*)	×	—	—
Goat (*Capra hircus*)	×	—	?
Ox (*Bos taurus*)	×	—	?
Field-mouse (*Mus sylvaticus*)	×	×	×
Rat (*Mus decumanus*)	×	—	—
Arctic Lemming (*Dicrostonyx torquatus*)	?	×	×
Rabbit (*Lepus cuniculus*)	×	×	?
Hare (*Lepus timidus = variabilis*)	×	×	×
Bear (*Ursus arctos*)	×	—	×
Dog (*Canis familiaris*)	×	?	?
Wolf (*Canis lupus*)	×	—	?
Fox (*Vulpes vulpes*)	×	—	×
Badger (*Meles taxus*)	×	—	—
Irish Stoat (*Putorius hibernicus*)	—	×	—
Man (*Homo sapiens*)	×	—	?

Erratic Blocks of the British Isles.—Report of the Committee, consisting of Mr. J. E. MARR (*Chairman*), Mr. P. F. KENDALL (*Secretary*), Professor T. G. BONNEY, Mr. C. E. DE RANCE, Professor W. J. SOLLAS, Mr. R. H. TIDDEMAN, Rev. S. N. HARRISON, Dr. J. HORNE, Mr. F. M. BURTON, Mr. J. LOMAS, Mr. A. R. DWERRYHOUSE, Mr. J. W. STATHER, Mr. W. T. TUCKER, *and* Mr. F. W. HARMER, *appointed to investigate the Erratic Blocks of the British Isles and to take measures for their preservation.* (*Drawn up by the Secretary.*)

THE records which have been transmitted to the Committee during the past year come from only two districts. The Boulder Committee of the Yorkshire Naturalists' Union continues its most valuable work over the entire county. Records which call for particular notice are the boulder of diabase at Aldfield, near Ripon (the most westerly point to which rocks foreign to the district have been traced), and the boulders of limestone at Escrick, which resemble some of the rocks of Swaledale. Carboniferous limestones rarely display characters by which their exact place of origin can be determined.

A visit paid by the Yorkshire Geological and Polytechnic Society to the Tweed Valley two years ago enabled members of the Yorkshire Boulder Committee to acquire a familiarity with some of the distinctive rocks of that region, with the result that the Haggis Rock, so well known to Scottish geologists, is reported from several localities in the east of Yorkshire.

The interest of these observations is, however, eclipsed by a remarkable series of boulders noted by Mr. H. B. Muff, now of the Geological Survey of Scotland. Mr. Muff submitted to his colleagues, Messrs. B. N. Peach and E. H. Cunningham-Craig, a series of specimens of boulders from the country round Whitby, and among them were recognised rocks from the Southern Uplands of Scotland, such as Haggis Rock, Queensbury grits, and radiolarian chert; Old Red Sandstone conglomerate of a Scottish type and various volcanic rocks of which the source may be in either the Cheviots, Pentlands, or Ochills. The authorities quoted consider that it is unsafe to assign porphyrites specifically to the Cheviots, as rocks of the same petrological character occur as far north as the Ochills. The succeeding determinations show that there is no improbability in this suggestion, for they include a large suite of quite distinctive Highland rocks, namely, Leny grits, Highland schists of Perthshire, Moine schists, and Ben Ledi grits.

Additional localities in Yorkshire are given for the Scandinavian rhomb porphyries, augite- and zircon-syenites, and the Secretary, Mr. Howarth, records a rock resembling the peculiar nodular gabbro of Imenæs, near Grimstad. A very satisfactory identification is that by Mr. Stather of a boulder absolutely identical in structure and constitution with the elæolite syenite (foyaite) of Kvelle, near Larvik.

It is gratifying to be able to announce at this meeting the resumption of its work by the Belfast Naturalists' Field Club. In past years (1895 and 1896) this society contributed most valuable and interesting reports to the Committee, and it is to be hoped that other organisations in Ireland will follow its example. The most noteworthy facts in the present report are, first, the very wide and general dispersal of the well-known riebeckite-eurite of Ailsa Craig. Out of forty localities which are mentioned in the Belfast society's lists no fewer than twenty-six have yielded this rock. The schedules, carefully compiled by Madame Christen and now presented, give in a condensed and convenient form the results of a large amount of patient and minute research, and might well be adopted as a model by any societies undertaking a survey of the erratic blocks and allied phenomena of a new field of study.

An appeal will be issued in the coming year to the Scottish societies to take up the work of observing and recording the erratics of the country, so that at least their general distribution may be roughed out. Dr. John Horne has promised his active co-operation in the determination of the sources of boulders observed.

An observation made at Dunbar during the present summer emphasises the necessity for guarding against the inclusion in lists of erratics of stones which have been transported by human agency. A block of zircon-syenite bearing a resemblance to a rock found at Larvik in Norway was found upon the beach; a specimen was submitted to the officers of the Geological Survey at Edinburgh, and their opinion was unanimous that it was not a Scottish rock. Renewed search was made at Dunbar, which resulted in the discovery of twenty or thirty small boulders of the quite unmistakable augite-syenite (laurvigite) of Larvik, and upon inquiry at the coastguard station the writer was informed that in the last ten years several Norwegian sailing-ships have been wrecked upon that particular piece of shore, so it may safely be assumed that these stones came as ballast. If they had been ice-borne boulders they would certainly have been accompanied by their invariable associates in the English glacial deposits, the rhomb-porphyries, which extend in Norway over a much wider outcrop than that of the laurvigites. Flints of the type found in the south of England are also very abundant on the beach at Dunbar.

YORKSHIRE.

Communicated by the Yorkshire Boulder Committee.
Reported by W. GREGSON, *F.G.S.*

Aldfield, five miles west of Ripon.—

1 diabase 11 in. by 7 in. by 5 in.
600 feet O.D. on millstone grit. No angles.

Reported by P. F. KENDALL, *F.G.S.*

Escrick, near York.—Several boulders of a Carboniferous limestone containing many brachiopods have been found here which are quite unlike anything I know in the Craven area. Mr. W. Horn, of Leyburn, says they are different from any limestone in Wensleydale, and suggests Swaledale as their place of origin. A single specimen had previously been submitted to me from the same locality of a yellowish very crystalline limestone, which I recognised as identical in colour and structure with that forming the matrix of specimens of *Woodocrinus* from the famous quarry near Richmond. The corroboration is interesting and may be valuable, as no distinctive Swaledale rock had previously been found in the Vale of York. The specimens were all found by Mr. E. M. Baines.

Coxwold.—In a quarry beside Shandy Hall and in digging foundations for a house a little nearer the village the erratics consisted mainly of Carboniferous sandstone, limestone, and chert, with a few small boulders (up to about 8 inches in diameter) of Borrowdale andesite. A special search was made for Cheviot porphyrites with negative results.

Kilburn.—At corner of a road ¼ mile S. of the village, Borrowdale andesitic ash containing many garnets. Roadside heap in the village, 1 Shap granite.

Reported by Rev. E. MAULE COLE, *M.A., F.G.S.*

Carnaby.—In digging a hole for a gate-post in the main street of the village on high road between Bridlington and Driffield.

1 Whin Sill 22 in. by 19 in. by 12 in., polished and flat.

The boulder now lies by the roadside opposite the blacksmith's shop.

Reported by H. B. MUFF, *B.Sc., F.G.S.*

The following boulders from East Yorkshire have been identified by B. N. Peach, Esq., F.R.S., F.G.S., and E. H. Cunningham-Craig, Esq., B.A., F.G.S., of the Geological Survey of Scotland, to whom Mr. Muff submitted them :—

Robin Hood's Bay.—Several beach boulders of andesites, porphyrites, and lamprophyres of Old Red Sandstone age from the Cheviot, Pentland, or Ochill Hills.

? Old Red Sandstone, Scotland, 1 specimen.
'Haggis' Rock, northern edge of Southern Uplands of Scotland, 1 specimen in Upper Boulder Clay.
Red Jasper (radiolarian chert), Southern Uplands of Scotland, beach boulder.
Leny grits, Highland schists, Perthshire; 1 specimen in Upper Boulder Clay; 1 specimen in beach boulder.
Epidiorite, Highland schists, Perthshire; 1 specimen, beach boulder.
Moine schist, Highlands, 1 specimen in Upper Boulder Clay.

Whitby.—

Lower Old Red Sandstone, Scotland; 1 specimen in Lower Boulder Clay.
Ophitic dolerite (coarse), similar to the sills of Carboniferous age in the 'Midland Valley' of Scotland; 1 specimen, beach boulder.

Stonegate, Erksdale.—

Queensbury grit, Southern Uplands of Scotland; 1 specimen; Leny Grits (?) 1 specimen.

Egton Brickworks, Eskdale.—

Ben Ledi grit, Highland schists, Perthshire, 1 specimen in Boulder Clay.

Most of these boulders have been sent to the Hull Municipal Museum.

HULL GEOLOGICAL SOCIETY.

Report of the Boulder Committee, August 1902.

Barton-on-Humber.—Quarry in glacial gravels, ½ mile west of the town. Gravel consists mainly of local chalk and flint, but foreign rocks also occur as follows :—

2 coarse conglomerates,	18 in.	in diameter.
1 glaciated basalt,	18 in.	,,
1 Cheviot porphyrite,	12 in.	,,

Amongst the smaller foreign pebbles Cheviot porphyrites are the most common, but magnesian limestone (Roker type), greywackes basalts, Carboniferous limestones, and lias also occurred.

Reported by Rev. E. MAULE COLE, *M.A., F.G.S.*

Driffield, in the Highfield Quarry.

Rhomb porphyry.

Reported by G. W. B. MACTURK.

Bluestone Bottoms, near Little Weighton.—In this wold valley, at an elevation of 250 feet above O.D., numbers of drift pebbles occur, Cheviot porphyrites being especially abundant.

Reported by James Fraser Robinson.

Wawne, near Hull.—

Pebbles of augite syenite, rhomb porphyry, basalt, greywacke, Cheviot porphyrite, black flint and pink flint.

Reported by Thomas Sheppard, *F.G.S.*

Easington (*beach*), *Holderness.*—

Shap granite. 8 in. by 8 in. by 8 in.

Meaux, near Hull.—

Quartzite 30 in. in diameter; pebbles of rhomb porphyry; Cheviot porphyrite; Carboniferous sandstone and dias.

Reported by J. W. Stather, *F.G.S*

Burstwick, Holderness.—

Foyaite (Brögger), Kvelle, 5 in. by 4 in. by 4 in.

Dimlington, Holderness.—

Zircon syenite, 2 small boulders.
Ångermanland granite, 10 in. by 5 in. by 5 in.
Coal-measure shale, with many Anthracosias, 6 in. by 4 in. by 2 in.
Pebble of chalk, with plate of *Marsupites ornatus* attached.

Middleton-on-the-Wolds.—In a gravel and sand-pit at west end of the village, 150 feet O.D., occurs gravel consisting chiefly of water-worn chalk and flint pebbles, with a small percentage of foreign pebbles, including—

Rhomb porphyry, coarse red granite, basalts, ganister and grits, many Cheviot porphyrites, lias (ammonites).

Out Newton, Holderness coast.—

Shap granite, 3 ft. by 2 ft. by 2 ft.

Wykeham, Vale of Pickering.—In a sand-pit behind the Down Arms Hotel.

A flint cast of *Ananchytes ovatus.*

Reported by F. F. Walton, *F.G.S.*

Aldbrough, Holderness.—

Haggis rock.

Hayburn Wyke.—

Haggis rock.

Hornsea, Holderness.—

Rhomb porphyry with amygdules.
Shap granite, 18 in. by 12 in. by (?).
ditto 8 in. by 5 in. by 3 in.
Bedded volcanic ash, probably Borrowdale series.
Lower Silurian conglomerates, greywackes (Queensbury grits), &c.

Reported by Rev. GEORGE STYLE, *M.A.*

Giggleswick.—On Grammar School Cricket Ground the pavilion is set back into a glacial moraine containing numerous rounded to sub-angular stones. They include millstone grits, Yoredale grits and shales, Hardraw Scar limestone, Lower Carboniferous limestones, and Silurian grits.

NOTE.—This deposit and the worn rocks and *roches moutonnées* from the school buildings on to the Settle golf-links, by the Ebbing and Flowing Well, suggest an ice-flow coming over Buck Ha' Brow. The moraine might, however, have been laid down by ice coming down Ribblesdale by Horton and Stainforth. Further evidence required.

Reported by J. H. HOWARTH, *F.G.S.*

Langcliffe, near Settle.—In cutting for engine-bed at Mr. Christie's mills by River Ribble through about 7 feet of top earth and drift with boulders, dark lower limestone *in situ* exposed, finely grooved and scratched and very highly polished. Striæ down valley.

Reported by W. SIMPSON, *F.G.S., and* J. H. HOWARTH, *F.G.S.*

Mytholmroyd, Calder Valley.—In cutting for sewage drain by bridge over canal in village.

Deposit containing many rounded boulders and fewer sub-angular. One to 2 feet of top earth. Boulders in sand 3 to 6 feet. Shales *in situ* below.

Borrowdale ash, 4 in. by 3 in. by 2 in., and numbers smaller.
Lake District andesites, few small pebbles.
Eskdale granite, 6 in. by 5 in. by 2 in and 3 in. by 3 in. by 2 in.
Ennerdale granophyre, 4 in. by 3 in. by 2 in.
Buttermere granophyre, pebble.
Rhyolite.

This deposit is on the opposite side of the River Calder to that reported previously by Messrs. Simpson and Law, and appears to be water-laid or re-sorted glacial débris.

Halifax, Calder Valley.—In making a roadway and drains for developing Willow Hall Estate between Sowerby Bridge and King Cross, Halifax, on the east side of the Calder Valley.

575 feet O.D., and 275 feet above the river, deposit of clay plastered along valley-side from 3 to 10 feet thick, and lying on shales below the Rough Rock.

The lower portion a stiff tenacious clay, almost stone-free. The upper a sandy clay, containing well-rounded to angular local rocks varying in size from pebbles to three or four large sub-angular blocks, the largest being 60 inches by 22 inches by 11 inches.

Gristhorp.—On beach.

Gabbro, similar to Imenæs, South Norway.
Porphyrites (Cheviot type) abundant.
Red jasper, Southern Uplands of Scotland.
Quartz porphyry.

IRELAND.

Communicated by the Belfast Naturalists' Field Club.

Investigations into the Glacial Drifts of the North-east of Ireland, with Special Reference to the Distribution of Erratics and Fossils. Conducted for the Belfast Naturalists' Field Club by Madame CHRISTEN, Miss MARY K. ANDREWS, *and* Mr. ROBERT BELL. *Microscopic Examinations conducted by* Mr. JOSEPH WRIGHT, *F.G.S., and* Miss SMYTHE. *The Determination of Rocks by* Professor GRENVILLE COLE, *F.G.S.*, Prof. W. W. WATTS, *M.A., F.G.S.*, Mr. A. MCHENRY (*Geological Survey*), *and* Mr. J. ST. J. PHILLIPS.

The following schedule has been prepared as a summary of the most important results of several years' work carried on by many members of the Belfast Naturalists' Field Club, and includes stray records from localities not fully examined, which have nevertheless furnished data sufficiently important to be worth recording. Fuller details will be subsequently published in the club's annual proceedings.

Erratics.—The prevalence of Ailsa Craig eurite is remarkable : it occurs at twenty-six of the scheduled localities as pebbles on the sands at Whitepark Bay, Portrush, and Portstewart, on the shores of Belfast Lough, and in dredgings off Rathlin Island at a depth of 45 fathoms. Scottish rocks have been found in several deposits, and others whose parent locality may be either Scotland or Ireland. Basalts and other rocks too widely distributed as rocks in the district to be of value in indicating lines of ice-flow have been omitted from the schedule for the sake of conciseness; nor has it been possible in these limits to include the compass direction of parent rocks, which will be more easily understood by reference to the map,[1] where the distribution of a few easily recognised erratics has been indicated. The term 'loose strong drift' is here applied to localities where the contents of boulder-clay cliffs have been scattered on the shore by the waves of the sea, as well as to loose drift, which is dispersed over headlands and mountains. No. 27 (Carronreagh Quarry) offered a solitary example of a peculiar rubbly deposit of angular fragments. Shells are very rarely found in the local drift, but microzoa, especially *Foraminifera*, are widely distributed. Their occurrence in such elevated deposits as No. 3 (Divis Mountain) and No. 7 (Cave Hill), and their absence from such a deposit as No. 32 (Killough) at sea level, is noteworthy. The boulder clays at No. 4 and No. 7 are not typical deposits, being scanty beds of hard clay filled with angular fragments of chalk, flint, and basalt only.

This invasion of the north-east of Ireland by an ice-flow from Scotland, the ensuing conflict between Irish and Scottish ice, and the ultimate lines of distribution over Ireland, offer a fascinating problem barely touched upon in these researches, and urgently calling for further investigations of the drift deposits scattered throughout Ulster.

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[1] The reference is to a map which will be published by the Belfast Naturalists' Field Club.

ose stony drifts = St.D. S
anite = Gran. Cretaceous = C

											Co. Armagh
5	16	17	18	1	34	35	36	37	38	39	40
	Gleno, near Glynn	Kilwaughter, near Larne	Drumsough and Ballylurgan, Cookstown Junction	Cranfield Point. N. Shore	Dromore	Newry	Mourne Mountains (Seefin and Sponkwee)	Bloody Bridge, near Newcastle	Colligan Bridge, E. Base of Mourne Mountains	Kilkeel, E. Coast of co. Down	Armagh City
0	387	825	200		300	90	Circa 800	100	415	O.D.	142
8	21	20	28	2	48	60	60	61	60	71	47
0	46	40	43	4	21	26	—	—	—	—	—
G.	B.C., S.G.	B.C.	B.C.	St	B.C.	B.C.	St.D.	S.G., St.D.	B.C.	St.D.	B.C.
r.	Un. Str.	Un.	Un.	U	Un.	Un.	Un.	Str.	Un.	Un.	Un.
s.	Chalk	Chalk	Bas.	B	Ord.	Bas.	Ord. & Gran.	Ord.	Gran.	Ord.	Carb. L.
il	Nil	Nil	Nil	1	Nil	Nil	—	Nil	—		—
—	—	Nil	Nil		For. (very	Nil	—	Nil	Rich For.	—	—
	—	—	—	—							
	—	—	—	—							
	—	—	—	—	—	×					
	—	—	—	—	—	×	—	×			
	—	—	—	—							

Occupation of a Table at the Zoological Station at Naples.—Report of the Committee, consisting of Professor W. A. HERDMAN (*Chairman*), Professor G. B. HOWES (*Secretary*), Professor E. RAY LANKESTER, Professor W. F. R. WELDON, Professor S. J. HICKSON, Mr. A. SEDGWICK, *and* Professor W. C. McINTOSH.

APPENDIX PAGE

I. *Report on the Occupation of the Table* 260

- *a. On the Structure and Development of the Excretory Apparatus of Amphioxus. By* E. S. GOODRICH, *M.A.* 260
- *b. On Trematodes and Cestodes parasitic on Fishes. By* NORMAN MACLAREN, *Esq.* 260
- *c. On the Algæ of the Bay of Naples. By* Miss ANNA VICKERS . . 262
- *d. On the Copepod Sub-family Ætidiinæ, with a proposed Revision of the Classification. By* R. NORRIS WOLFENDEN, *M.D. Cantab., F.Z.S.* 263

II. *A List of Naturalists who have worked at the Zoological Station from the end of June* 1901 *to the end of June* 1902 267

III. *A List of Papers which were published in the year* 1901 *by the Naturalists who have occupied Tables in the Zoological Station* 269

IV. *A List of the Publications of the Zoological Station during the year ending June* 30, 1902 270

OWING to circumstances which transpired in the interval between application and the intended commencement of work for which the grant for 1902 was obtained, Messrs. Wallace and Gurney were both rendered incapable of fulfilling their task, Mr. Gurney having been forbidden by his medical adviser to journey afield under risk of injury to his health. Your Committee report the securing of substitutes whose names are given above, and whose work has been in each case a success. And they are desired by Mr. Wallace to state that he renews his application for the use of a Table during the coming year, and that he proposes to study 'Variation and Gestation in the Selachii.'

In a letter received from Dr. Anton Dohrn, special mention is made of his ability to endorse his surmise of 1901 as to his intention of erecting and equipping a new laboratory for comparative physiological research. He informs your Committee that the Town Council of Naples have unanimously voted an area of land of 600 square metres, in immediate proximity to the two historical buildings now in use, as a site for the laboratory aforementioned; and it is with satisfaction that your Committee are enabled to report that funds sufficient for the undertaking are guaranteed, through the generosity of personal friends of Dr. Dohrn, and that plans for the building are now prepared.

The work of construction will be commenced in autumn, and it is expected that the laboratory will be finished and fully equipped by Easter, 1904.

Dr. Dohrn lays stress on the fact that for a very considerable contribution to the cost of the new building he is indebted to an English friend, and your Committee re-echo his hope that this may further cement the tie with the British Association, and that the range of the work of those who in future may visit the Station on its behalf shall be commensurate with the Station's increased facilities and growth.

In presenting the reports of the occupants of the Table during the present year, your Committee desire to point out that on emergency willing and competent persons were but awaiting their appeal. Reassured by this, in applying for a renewal of the grant they have every confidence in the future; and they are of opinion that the increased facilities aforenamed, by widening the field of action, will more than ever incur the favourable consideration of the Association's Board.

APPENDIX.

I. *Report on the Occupation of the Table during December* 1901 *and January, June, and July* 1902.

a. On the Structure and Development of the Excretory Apparatus of Amphioxus. By E. S. Goodrich, *M.A. Oxon.*

During the latter end of December 1901 and most of January 1902 I occupied the British Association Table at the Zoological Station in Naples. I had then the opportunity of examining the structure of the excretory organs of Amphioxus in fresh and preserved specimens. As a result of this study, it was discovered that the kidneys of Amphioxus are not, as had hitherto been supposed to be the case, segmental tubules opening by many funnels into the cœlom, and comparable to the excretory organs of the higher vertebrates; but, on the contrary, that these kidneys are in the form of tubules opening only to the exterior (atrium), and produced internally into blind branches. Moreover, it was found that these internal extremities are provided with numerous peculiar cells (incompletely described by Boveri) perched on the free ends of long and narrow tubes, down each of which works a single flagellum driving the excretory fluids into the renal canal. These cells exactly resemble the excretory cells (Solenocytes) which I have described as situated on the inner blind ends of the nephridia of certain Polychæte worms. It would appear, then, that the kidneys of Amphioxus are, physiologically and morphologically, strictly comparable to the nephridia of certain Annelids.

The results of this work have been embodied in a preliminary note read last January before the Royal Society, and in a more complete and illustrated memoir published in the 'Quarterly Journal of Microscopical Science.'

In June and in this month of July 1902 I have again had the privilege of occupying the British Association Table in Naples, and am engaged in working out the development of the excretory organs of the larval Phoronis and Amphioxus.

Report on the Occupation of the Table during March and April 1902.

b. On Trematodes and Cestodes parasitic in Fishes. By Norman Maclaren.

During the six weeks in which it was my privilege to work at the Stazione Zoologica this spring I confined myself almost entirely to collecting material (Trematodes and Cestodes) for future anatomical investigations. Upwards of two hundred fishes were examined, and numerous specimens were collected.

One of the most interesting species obtained was a hitherto undescribed Didymozoon from the gills of a young Orthagoriscus mola. There were four cysts on the same fish, varying in size from 1 to 3 cm. long and about 1 cm. thick. The worms are so intricately wound together that it is exceedingly difficult to isolate a single individual; but judging from fragments from the largest cyst, each worm must be from one to two metres long. Attempts to induce the eggs to develop were quite unsuccessful. There is a similar Didymozoon—also from Orthagoriscus—in the museum of Genoa University.

I am at present occupied with material obtained at Naples, and hope to shortly publish some of my results. Appended is a list of the fishes examined, and I regret that owing to other work I have not yet had time to identify all their parasites.

I would desire to express my great obligations to the British Association for permission to work at their table, and also to the officials of the Stazione Zoologica for their unfailing kindness.

Fish	No.	Parasite	Remarks
Belone acus	4	Scolex sp.	Abundant in stomach
Centrophorus granulosus	1	—	—
Cernua gigas	4	—	—
Chrysophrys aurata	2	Distomum obovatum (Molin)	One specimen in intestine.
Clupea aurita	7	Scolex sp.	Abundant in one specimen; encysted in append. pyl.
Conger vulgaris	8	Distomum rufoviride (Rud.)	Abundant in stomach.
Corvina nigra	8	—	—
Dentex gigas	1	—	—
Dentex vulgaris	8	Distomum megastomum (Rud.)	One specimen in stomach.
Galeus canis	1	Tetrarhynchus sp.	In spiral fold; abundant.
Hexanchus griseus	3	Distomum veleporum (Crep.)	Two specimens in one stomach.
Labrax lupus	37	Tetrarhynchus sp.	In stomach of one.
		Bothriocephalus sp.	In intestine of one.
		Tetraonchus sp.	Seventeen on gills of two specimens.
		Scolex sp.	In pylorus; abundant.
Lepidopus caudatus	1	Echinorhynchus sp.	One specimen in intestine.
		Scolex sp.	In gall bladder; abundant.
Lichia glauca	1	—	—
Lophius piscatorius	1	—	—
Merlucius lupus	5	Scolex sp.	A few in the intestine.
Merlucius vulgaris	25	Scolex sp.	Two in the stomach.
Mugil cephalus	many	—	—
Mullus barbatus	7	—	—
Mullus surmuletus	6	—	—
Mustelus lævis	10	Distomum megastomum (Rud.)	Seven in the stomach.
		Distomum sp.	Numerous in the stomach.
		Distomum sp.	Abundant; encysted in walls of the stomach.
		Onchobothrium sp.	In spiral fold; abundant.
		Tetrarhynchus sp.	Nine in the stomach
Mustelus vulgaris	2	Calliobothrium filicolle (Zsch.)	In spiral fold of one specimen; abundant.
Myliobatis aquila	1	Tetrarhynchus sp.	In spiral fold; numerous.

Fish	No.	Parasite	Remarks
Oblata melanura	7	Distomum obovatum (Molin)	One in pharynx.
Orthagoriscus mola	3	Distomum nigroflavum (Rud.)	Seven in two intestines.
		Distomum contortum (Rud.)	Four in mouth of one specimen.
		Echinostoma lydiæ (Stoss.)	In one intestine; abundant.
		Didymozoon sp.	Four cysts on gills of one specimen.
		Tristomum molæ (Blanch.)	One on skin.
		Bothriocephalus microcephalus (Rud.)	Fourteen in intestine of one specimen; five in another.
		Anthocephalus elongatus (Rud.)	In liver and muscles.
		Scolex sp.	Several in one intestine.
Pelamys sarda	19	Tetrarhynchus sp.	Five in three stomachs.
		Scolex sp.	Several in one intestine.
Raja asterias	3	—	—
Rhombus maximus	10	Bothriocephalus punctatus (Rud.)	In intestine; abundant.
		Scolex sp.	In intestine; abundant.
		Distomum rufoviride (Rud.)	Seven in one stomach.
Scorpæna porcus	2	—	—
Scorpæna scropha	9	Distomum granulum (Rud.)?	One in one intestine.
Scyllium canicula	3	—	—
Sebastes imperialis	3	—	—
Solea vulgaris	6	—	—
Squatina angelus	1	—	—
Torpedo marmorata	2	Phyllobothrium sp.	In spiral fold of one specimen.
Torpedo ocellata	5	Onchobothrium uncinatum (Rud.)	A few in spiral fold of intestine.
		Amphibdella torpedinis (Chatin.)	Numerous on gills.
Trygon pastinaca	1	Tetrarhynchus sp.	Numerous in spiral fold.
		Phyllobothrium sp.	Numerous in spiral fold.
Umbrina cirrhosa	10	Distoma tubarium (Rud.)	One in stomach.
Zeus faber	4	Bothriocephalus sp.	One in stomach.

Report on the Occupation of the Table from January to April 1902.

c. On the Algæ of the Bay of Naples. By Miss ANNA VICKERS.

My work at the Zoological Station in Naples from the beginning of January to April 12 was chiefly on material I brought myself from Barbados. I was able during that time to finish a certain number of drawings for a work which I hope to publish on the Algæ of Barbados. It is to be a *Phycologia* of the island, which I intend to complete from fresh material next winter on my return to Barbados. It is not easy to work on dry algæ. They have to go through such delicate handling, and even then with all the reactives used the cells scarcely get their original shape again. The acids tend to swell the tissues to an exaggerated size, if they are not stopped in their development just at the right moment. Therefore algæ preserved in alcohol are much easier to study and dissect.

At the same time as I sketched the Barbadian algæ of the Dictyota family I had fresh dictyota brought to me from the Bay of Naples, so as to be able to compare the structure of these plants with the West Indian species. The Barbadian dictyota and those of the West Indies in general are not very well known, the species being numerous and somewhat mixed up one with another; it will therefore be an interesting task to study them more perfectly and try to arrive at a system of classifying them more easily, which is not a slight task.

I asked at Naples for rare species of the Golfe Algæ, principally Rhodophycæ, and had brought me some specimens of Chrysymenia ventricosa and Platoma cyclocolpa or Nemastoma cyclocolpa. Thus I was able to continue my study of the algæ of the Bay of Naples at the same time that I worked at my principal object of study. It is a good thing to have plenty of work on hand, for it would be too monotonous to work all the time on dry material without getting a few fresh algæ now and then. The sea was often rough and stormy, as it generally is in winter at Naples, and the fresh material could not always be reached, so I was often very glad to have my own material to fall back upon when the other was wanting.

I once more thank the British Association for the permission granted me to work at the Association Table: it has been a great boon to me, and I hope that my work will turn out to be satisfactory to the algological world. It is a difficult one, but I am greatly helped and encouraged by Monsieur Bornet, without whose aid I would not have had the courage to undertake such a task.

Report on the Occupation of the Table during April and May 1902.

d. On the Copepod Sub-family Ætidiinæ, with a proposed Revision of the Classification. By R. NORRIS WOLFENDEN, *M.D. Cantab., F.Z.S.*

The Faroe Channel is especially rich, amongst Copepods, in examples of the sub-family *Ætidiinæ*. Several of these are new species, and during the author's plankton investigations in this region, extending over a period of three years, he has met with several forms of great interest. While the author's results remain as yet unpublished, pending the conclusion of his work, Professor G. O. Sars has lately published an important work dealing with the Crustacean fauna of Norway, in which he describes some of these new Copepod forms. It appeared to the author that the large sub-family *Ætidiinæ* required revision, and through the courtesy of the Council of the British Association and of Professor Dohrn he was in May 1902 allowed the privilege of occupying the Association Table at the Naples Zoological Station, where he had the opportunity of examining in detail the Copepod preparations made by Dr. Giesbrecht and comparing with his own Faroe collections. To Professor G. B. Howes and Drs. Anton Dohrn, Eisig, and Giesbrecht the author's warmest thanks are due.

The character of the sub-family *Ætidiinæ* are sufficiently well set forth in Dr. Giesbrecht's great work ('Fauna ü. Flora Neapel').

It is, however, evident that the segmentation of the feet cannot be employed as a definite factor in the classification of genera. For instance in the genus *Ætideus* which comprises the well-known species *Ætideus* *armatus*, we must now recognise a species of southern or Mediterranean origin, in which the endopodite of the second foot consists of only one segment, while in the Faroe Channel and northern regions a species very closely congeneric has a definitely biarticulate endopodite. Other points of difference exist in the character of the rostrum and the spiny prolongations of the last thoracic segments, both of which in the southern species are much stronger. Possibly a third species of *Ætideus* exists in the examples recorded by Brady from the Indian Ocean and described in the 'Challenger' reports; but this species must for the present remain in doubt, since it has not been met with again. The author would remark that in a collection of Copepods made by Mr. J. Stanley Gardiner in the Maldive Islands and forwarded to him for examination, he has not met with a single example of *Ætideus*.

Similarly in the genus *Gaidius* (Giesbrecht) there is one species having a uniarticulate endopodite of the second foot, and another species in which this ramus is biarticulate. The exopodites of the first feet also show irregularity in their segmentation. For instance, the genera *Ætideus*, *Bradyidius*, *Bryaxis*, *Chiridius*, have this appendage triarticulate, while in *Gaidius* and *Gaetanus* it is biarticulate, or in one species of the latter (*G. armiger*) three-jointed.

The appendages of the first basal joint of the fourth pair of feet become of importance generically. In his original description of the genus *Gaidius* Giesbrecht had already remarked upon the peculiar transformation of the bristles of this joint into lamellar appendages, as transitional to the spines of *Euchirella*. These modified bristles, which appear to be hollow tubes, are very characteristic of the genera *Gaidius* and *Gaetanus*. They are replaced by spines and teeth in the genus *Euchirella*. The character of the rostrum and its presence or absence appear to form a satisfactory basis for the classification of the genera of the sub-family *Ætidiinæ*, and have been adopted in the present scheme.

Recently Professor Sars has expressed the opinion that the genus *Gaidius* (Giesbrecht) should be abolished, and he has considerably extended the genus *Chiridius* by inclusion of three species (*Ch. tenuispinus*, *Ch. obtusifrons*, and *Ch. armatus*). But the genus as originally proposed by Giesbrecht, to include the only species known as yet, viz., *Ch. poppei*, appears to differ very considerably from Sars' genus *Chiridius*; and one of the latter species, viz., *Ch. tenuispinus* (Sars), is undoubtedly identical with Giesbrecht's *Gaidius*. One essential point of generic difference is the absence of a rostrum in Giesbrecht's genus *Chiridius*, and its presence in two at least of Sars' species (*Ch. tenuispinus* and *Ch. armatus*). Professor Sars lately had the kindness to forward to me examples of these three Copepods from his own collections, and from a comparison of Giesbrecht's preparations I have no doubt in affirming that *Chiridius tenuispinus*, Sars, is identical with Giesbrecht's *Gaidius*, and with specimens which the author had described previously as *Gaidius*.[1] In addition to the presence of a rostrum, the bristles of the first basal joint of the fourth pair of feet are modified into tubal processes exactly as in *Gaidius pungens* (Giesbrecht).

The genus *Chiridius*, as at first proposed by Giesbrecht ('Fauna ü. Flora Neapel,' v. 19), included only one species. It differs from all other genera of this group, in the fact of the outer branch of the posterior antennæ being twice as long as the inner, and in the presence of only eight bristles on the exopodite of the maxilla. It is further without any trace of rostrum, and is a small creature of only 1·8 mm. length. It appears to be so generically distinct from the northern forms included by Sars in this genus (one of which is undoubtedly a *Gaidius*) that it appears more satisfactory to retain the generic name *Chiridius* for the one species (*Ch. poppei*, Gbt.) for which it was originally created, and to place the northern forms, all of which are two or three times the size of the Mediterranean species, in another genus. These various genera will group themselves naturally in the following manner :—

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[1] See *Journ. Brit. Marine Biol. Assoc.*, 1901.

A. With a two-pointed rostrum.
Ætideus, Brady, *Pseudætideus* (nov. gen.), *Bradyidius*, Gbt.

B. With a one-pointed rostrum.
Gaidius, Gbt., *Gaetanus*, Gbt., *Chirundina*, Gbt.
Undeuchæta, Gbt., *Euchirella*, Gbt.

C. Without rostrum.
Chiridius, Gbt., *Bryaxis*, Sars.

Under this scheme the genus *Chiridius* (Sars) disappears and a new genus, *Pseudætideus*, is suggested, which includes Sars' species *Chiridius armatus*, and another entirely new species discovered by the author in the Faroe Channel. Sars' *Chiridius tenuispinus* is removed to its true family *Gaidius*, and his *Chiridius obtusifrons* should more properly perhaps be regarded as a *Chiridius*. There does not seem to be sufficient reason to exchange the name *Bradyidius* (Gbt.) to *Undinopsis* (Sars), and the former is therefore retained.

Vanhöffen (in Grönland Expedition, 1891–93, Berlin, 1897, Copepoden, vi. Kapitel, p. 279) described very briefly a Copepod captured in Greenland, which he regarded as identical with *Pseudocalanus armatus*, Boeck, but three times the size. Only one male was found in forty-five animals taken. But the prolongation of the last thoracic segment into lateral spines removes it from this genus. The author has met with one ♂ example of this Copepod in the Faroe Channel, but feels unable to place it generically, in the absence of ♀ examples, which, according to the general rule, may differ widely as regards the rostrum, proportions of the body, and character of the mouth parts.

Of the different genera and species of the sub-family *Ætidiinæ* the following occur in the Faroe Channel or off the coast of Norway :—

Ætideus tenuirostris . .	a surface form.
Pseudætideus armatus . .	found only in deep water, below 100 fathoms.
,, multiserrata .	
Bradyidius armatus . .	bottom forms, in shallow waters.
,, similis . . .	
Gaidius pungens . . .	deep-water forms, below 100 fathoms.
,, boreale . . .	
Gaetanus armiger . . .	ditto.
,, miles . . .	
Euchirella rostrata . .	ditto.
,, carinata . .	
Chiridius obtusifrons . .	a deep-water form from 200–800 fathoms (Sars).
Bryaxis brevicornis . .	a bottom form from 50–150 fathoms (Sars).

Undeuchæta and *Chirundina* have not yet been met with in northern waters, and *Chiridius poppei* appears to be exclusively a Mediterranean species. *Pseudætideus, Gaidius, Gaetanus, Euchirella* appear not to approach the coasts, the only genera which do so being, apparently, *Ætideus* and *Bradyidius*.

The scheme which follows is the merest outline, and will be more fully elaborated subsequently in a monograph dealing with the Copepoda of the Faroe Channel.

A. *Head with a two-pointed rostrum.*[1]

I. *First joint of exopodite of the first foot without external spines.*

1. Last thoracic segment produced into strong spines. Rami of mandible and posterior antennæ nearly equal. Basal joints of posterior foot-jaw equal and endopodite two-thirds as long. Endopodite of first foot one-jointed; of second foot one or two jointed; bristles of first basal of fourth foot simple =genus *Ætideus* (Brady).

Three species—*Æt. armatus*, Gbt., *Æt. tenuirostris* (n. sp.), *Æt. bradyi* (Brady).

II. *First joint of exopodite of first foot with an external spine; thoracic spines on last segment.*

2. Outer rami of posterior antennæ and mandible longer than inner; second basal of posterior foot-jaw longer than the first, endopodite only one-half to one-third as long as the second basal. Inner ramus of first foot one-jointed, of second two-jointed. Bristle of basal of fourth foot simple=genus *Pseudætideus*, nov. gen.

Two species—*Pseud. armatus* (*Chiridius armatus*, Sars), *Pseud. multiserrata*, n. sp.

3. Anterior antennæ with thick basal joints, tapering distally, twenty-four-jointed, and densely clothed with long cross-ringed bristles. Endopodite of posterior foot-jaw little more than half as long as the second basal=genus *Bradyidius*, Gbt.

Two species—*B. armatus*, Gbt. (*Undinopsis bradyi*, Sars), *B. similis* (*Und. similis*, Sars).

B. *Head with a short one-pointed rostrum.*

I. *Last thoracic segments produced into spines or angular processes.*

4. Outer rami of posterior antennæ and mandible longer than inner, second basal of posterior foot-jaw three to four times as long as endopodite, outer ramus of first foot of only two or of three segments; inner rami of second foot one or two jointed, first basal of fourth foot with bristles replaced by tubal processes=genus *Gaidius*, Gbt.

Two species—*G. pungens* Gbt., *G. boreale* (n. sp.) (*Chiridius tenuispinus*, Sars).

5. Head with characteristic dorsal spine; other characters like Gaidius=genus *Gaetanus*, Gbt.

Two species—*G. armiger*, Gbt., *G. miles*, Gbt.

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[1] The species diagnosis is omitted in this Report.

6. Last thoracic segment produced into blunt angles, not spines. Outer branch of posterior antennæ twice as long as inner, endopodite of posterior foot-jaw only quarter as long as second basal; first basal of fourth foot almost naked=genus *Chirundina*, Gbt.

One species—*Ch. streetsii*, Gbt.

II. *Last thoracic segments rounded, not produced into spines or angles.*

7. Head with or without a crest, outer rami of posterior antennæ not twice as long as inner, exopodite of the maxilla small, and its middle bristles the shortest. Endopodites of first and second feet one-jointed=genus *Undeuchæta*, Gbt.

Two species—*U. major*, Gbt., *U. minor*, Gbt.

8. Rostrum sometimes absent. Outer rami of posterior antennæ two to four times as long as inner. Head sometimes with a crest. Endopodite of first and second feet one-jointed. First basal of fourth foot armed with characteristic spines =genus *Euchirella*, Gbt.

Species—*Vide* Giesbrecht u. Schmeil, 'Thierreich,' p. 35.

C. *Head without rostrum.*

9. Outer branches of posterior antennæ and mandibles twice as long as inner; endopodite of posterior foot-jaw not half the length of second basal; exopodite of maxilla with eight to ten bristles; exopodite of first foot with three segments, first segment with bristle; endopodite of first foot one-jointed, of second one-jointed (trace of articulation); third and fourth feet three or two jointed; basals of fourth foot with simple basis=genus *Chiridius*, Gbt.

Two species—*Ch. poppei*, Gbt., *Chiridius obtusifrons* (Sars).

10. Thorax ending in acute upturned lappets. Anterior antennæ shorter than thorax, densely bristled. Inner ramus of posterior antennæ more than twice the length of outer, and only six-jointed. Posterior foot-jaws with sensory appendage on first basal=genus *Bryaxis*, Sars.

One species—*B. brevicornis*, Sars.

II.—*A List of Naturalists who have worked at the Zoological Station from the end of June* 1901 *to the end of June* 1902.

Number on List	Naturalist's Name	State or University whose Table was made use of	Duration of Occupancy	
			Arrival	Departure
1255	Prof. A. Dogiel	Russia	July 6, 1901	July 8, 1901
1256	Dr. J. Rioja y Martin	Zoolog. Station	„ 11, „	Mar 10, 1902
1257	Prof. S. Apáthy	Hungary	„ 26, „	Sept.13, 1901
1258	Dr. V. Ariola	Italy	„ 30, „	Oct. 9, „
1259	Prof. F. Raffaele	„	„ 30, „	Nov. 17, „
1260	Dr. F. Bottazzi	„	Aug. 5, „	Sept.15, „
1261	Dr. J. Boeke	Holland	„ 8, „	Nov. 2, „
1262	Stud. E. Wolff	Würtemberg	„ 21, „	Sept.20, „
1263	Dr. E. Crisafulli	Italy	„ 15, „	May 23, „
1264	Dr. A. Kouliabko	Russia	„ 23, „	Sept.14, „
1265	Dr. F. Mazza	Italy	„ 26, „	„ 15, „
1266	Dr. A. Bethe	Strasburg	„ 28 „	Oct. 24 „

A LIST OF NATURALISTS—*continued.*

Number on List	Naturalist's Name	State or University whose Table was made use of	Duration of Occupancy	
			Arrival	Departure
1267	Prof. P. Francotte	Belgium	Aug. 29, 1901	Oct. 19, 1901
1268	Dr. P. Enriques	Italy	„ 30, „	„ 18, „
1269	Dr. M. Schmidt	Prussia	Sept. 1, „	Sept. 4, „
1270	Prof. F. Sanfelice	Italy	„ 1, „	Nov. 15, „
1271	Prof. A. Russo	„	„ 2, „	Oct. 16, „
1272	Prof. J. Czokor	Austria	„ 2, „	„ 14, „
1273	Dr. F. Marino	Italy	„ 15, „	Nov. 7, „
1274	Stud. Andreae	Switzerland	„ 19, „	Oct. 15, „
1275	Stud. Miescher	„	„ 19, „	„ 15, „
1276	Miss N. Stevens	American Women's Table	Oct. 6, „	Apr. 5, 1902
1277	Mr. E. G. Schuster	Oxford	„ 8, „	June 15, „
1278	Dr. E. Teichmann	Prussia	„ 16, „	Apr. 12, „
1279	Prof. T. Boveri	Bavaria	„ 19, „	Apr. 23, „
1280	Dr. H. Driesch	Hamburg	„ 25, „	„ 12, „
1281	Dr. C. Herbst	Baden	„ 25, „	„ 20, „
1282	Dr. G. Tavaro	Italy	Nov. 1, „	Feb. 28, „
1283	Baron J. v. Uexküll	Prussia	„ 9, „	—
1284	Dr. Schücking	Pyrmont	„ 23, „	Jan. 7, „
1285	Dr. v. Dungern	Prussia	Dec. 2, „	Apr. 12, „
1286	Dr. A. Romano	Italy	„ 3, „	Mar. 15, „
1287	Dr. Creswell Shearer	Cambridge	„ 3, „	—
1288	Prof. L. Bolk	Holland	„ 7, „	Jan. 22, „
1289	Dr. C. H. Kappers	„	„ 9, „	Mar. 4, „
1290	Mr. E. S. Goodrich	*British Association*	„ 10, „	Jan. 10, „
1291	Dr. G. Illig	Saxony	„ 30, „	Mar. 3, „
1292	Dr. A. Nathansohn	„	Jan. 1, 1902	—
1293	Dr. M. Sciuti	Italy	„ 1, „	—
1294	Dr. G. Jatta	„	„ 1, „	—
1295	Dr. G. Tagliani	„	„ 1, „	—
1296	Dr. V. Diamare	„	„ 1, „	—
1297	Dr. U. Pierantoni	„	„ 1, „	—
1298	Prof. T. d'Evant	„	„ 1, „	—
1299	Dr. G. Rossi	„	„ 1, „	—
1300	Prof. C. Gioffredi	„	„ 1, „	—
1301	Dr. Presuhn	Prussia	„ 1, „	June 1, 1902
1302	Miss A. Vickers	*British Association*	„ 8, „	Apr. 18, „
1303	Prof. H. Rabl	Austria	„ 12, „	Mar. 3, „
1304	Dr. R. Issel	Italy	„ 22, „	June 8, „
1305	Mr. L. Doncaster	Cambridge	Feb. 18, „	—
1306	Dr. A. Ernst	Switzerland	„ 20, „	Apr. 10, „
1307	Dr. E. Godlewski	Austria	„ 21, „	—
1308	Dr. M. Bedot	Switzerland	„ 26, „	Mar. 23, „
1309	Dr. R. Magnus	Hesse	Mar. 4, „	Apr. 22, „
1310	Dr. O. Cohnheim	Zoolog. Station	„ 6, „	„ 22, „
1311	Dr. C. Prentiss	Smithsonian Institution	„ 7, „	—
1312	Mr. N. Maclaren	*British Association*	„ 8, „	Apr. 22, „
1313	Dr. R. Woltereck	Prussia	„ 14, „	„ 9, „
1314	Dr. W. Kotzenberg	Bavaria	„ 15, „	„ 14, „
1315	Prof. Hess	„	„ 15, „	„ 4, „
1316	Prof. O. Zur Strassen	Saxony	„ 18, „	„ 24, „
1317	Dr. H. Winkler	Würtemberg	„ 24, „	„ 22, „
1318	Dr. J. Tandler	Austria	„ 27, „	May 21, „
1319	Dr. T. Tobler	Prussia	„ 28, „	—
1320	Prof. K. Kostanecki	Austria	Apr. 1, „	May 6, „
1321	Dr. R. Wolfenden	*British Association*	„ 2, „	„ 1, „

A LIST OF NATURALISTS—*continued*.

Number on List	Naturalist's Name	State or University whose Table was made use of	Duration of Occupancy	
			Arrival	Departure
1322	Prof. C. Julin	Belgium	Apr. 2, 1902	May 22, 1902
1323	Prof. L. Muskens	Holland	„ 4, „	Apr. 25, „
1324	Prof. W. Schewiakoff	Russia	„ 7, „	—
1325	Dr. W. Schweyer	„	„ 7, „	—
1326	Dr. B. Soukatchoff	„	„ 7, „	—
1327	Dr. C. Addaro	Italy	May 15, „	—
1328	Dr. de Groot	Holland	„ 24, „	June 11, 1902
1329	Prof. W. Palladine	Russia	„ 28, „	—
1330	Dr. K. Derjugin	„	June 11, „	—
1331	Prof. T. H. Morgan	Smithsonian Institution	„ 13, „	—
1332	Dr. R. Dalla Vedova	Italy	„ 16, „	—
1333	Stud. S. Awerinzoff	Russia	„ 18, „	—
1334	Stud. V. Dogiel	„	„ 21, „	—
1335	Mr. E. S. Goodrich	*British Association*	„ 21, „	—

III.—*A List of Papers which were published in the year* 1901 *by the Naturalists who have occupied Tables in the Zoological Station.*

H. Przibram	Experimentelle Studien über Regeneration. Arch. f. Entw. Mechanik, 11 Bd.
E. Weinland	Zur Magenverdauung der Haifische. Zeitschr. f. Biologie, 41 Bd.
„	Ueber den Glykogengehalt einiger parasitischer Würmer. *Ibid.*
D. Carazzi	Studi sui Molluschi. Intern. Monatsschrift f. Anat. u. Physiol. 18 Bd.
M. Henze	Ueber ein Vorkommen freier Asparaginsäure im thierischen Organismus. Ber. deutsche Chem. Ges. Jgg. 34.
„	Zur Kenntniss des Hämocyanins. Hoppe-Seyler's Zeitschr. f. Phys. Chemie, 33 Bd.
„	Ueber den Kupfergehalt der Cephalopodenleber. *Ibid.*
F. Kopsch	Die Entstehung des Dottersackentoblasts und die Furchung bei Belone acus. Internat. Monatsschr. f. Anat. u. Physiologie, 18 Bd.
A. Ónodi	Das Ganglion ciliare. Anatom. Anzeiger, 19 Bd.
F. Bottazzi	Contributi alla fisiologia comparata della digestione. Arch. Biologia norm. e patologica, Anno 54.
„	Ueber die Innervation des Herzens von Scyllium canicula u. Maja squinado. Centralblatt für Physiologie, 1901.
v. Dungern	Die Ursachen der Specietät bei der Befruchtung. *Ibid.*
„	Neue Versuche zur Physiologie der Befruchtung, I. u. II. Zeitschr. f. allgem. Physiologie, 1 Bd.
F. Capobianco	Della influenza di agenti fisico-chimici sovra la eccitabilità dei nervi e dei muscoli lisci negli Invertebrati. Atti R. Accad. Sc. fis. e mat. Napoli, vol. 10.
C. Herbst	Ueber die zur Entwickelung der Seeigellarven nothwendigen anorganischen Stoffe, ihre Rolle und Vertretbarkeit. II. Theil. Arch. f. Entw. Mechanik, Roux. 11 Bd.
„	Ueber die Regeneration von antennenähnlichen Organen an Stelle von Augen. V. *Ibid.* 13 Bd.
G. Rossi	Sul sistema nervoso sottintestinale dei Miriapodi. Rendic. R. Acc. Lincei, vol. 10.
„	Un nido di Julus. Zool. Anzeiger, 24 Bd.
„	Sulla locomozione dei Miriapodi. Atti Soc. Ligustica, vol. 12.

H. Jordan . . .	Die Physiologie der Locomotion bei Aplysia limacina. Dissertation, Zeitschr. Biolog. 41 Bd.
T. H. Morgan . . .	The factors that determine Regeneration in Antennularia. Biological Bulletin, Boston, vol. 2.
P. Bottazzi and P. Enriques.	Ueber die Bedingungen des osmotischen Gleichgewichts bei Wasserthieren. I. Die osmotischen Eigenschaften der Magenwand der Aplysien. Arch. Anat. u. Physiol., Physiol. Abth. 1901.
A. Russo . . .	Sullo sviluppo dell' apparato madreporico di Antedon. Nota. Zool. Anzeiger, 24 Bd.
V. Diamare . . .	Cisti epiteliali nel cosidetto pancreas dei Petromizonti. Rendic. Conv. Unione Zoolog. Ital. Napoli, 1901.
U. Pierantoni . . .	Sopra una nuova specie di Oligochete marino (Enchytræus macrochætus). *Ibid.*
R. Woltereck . . .	Ueber den feineren Bau der Polygordinslarve der Nordsee, etc. Habilitationsschrift, Leipzig, 1901.
M. Siedlecki . . .	Sur les rapports des Grégarines avec l'épithélium. Comptes Rendus Hebd., Soc. de Biologie, Tome 53.
E. Meyer . . .	Studien über den Körperbau der Anneliden. Mitth. Zool. Station, Neapel, 14 Bd.
J. von Uexküll . .	Die Schwimmbewegungen von Rhizostoma pulmo. *Ibid.*
W. Straub . . .	Zur Physiologie des Aplysienherzens. Archiv f. d. ges. Physiologie, 86 Bd.
,, . . .	Toxicologische Untersuchungen am Selachierherzen. Zeitschr. f. Biologie, 42 Bd.
E. S. Goodrich . .	On the structure and affinities of Saccocirrus. Quart. Journ. Micr. Sc., vol. 44.
J. Boeke. . . .	Die Bedeutung des Infundibulums in der Entwickelung der Knochenfische. Anatom. Anzeiger, 20 Bd.
O. Cohnheim . . .	Versuche über Resorption, Verdauung und Stoffwechsel von Echinodermen. Zeitschr. f. Physiol. Chemie, 33 Bd.
E. Riggenbach . .	Beobachtungen über Selbstverstümmelung. Zool. Anzeiger, 24 Bd.
H. Miehe . . .	Crapula intrudens, ein neuer mariner Flagellat. Ber. deutsche Botan. Ges. 19 Bd.
H. Winkler . . .	Ueber Merogonie und Befruchtung. Jahrb. f. wiss. Botanik, 36 Bd.
O. von Fürth . . .	Ueber Glykoproteide niederer Thiere. Zeitschr. f. d. ges. Biochemie, 1 Bd.
L. Fredericq . . .	Sur la concentration moléculaire du sang et des tissus chez les animaux aquatiques. Bull. de l'Acad. Roy. de Belgique, No. 8.
P. Enriques . .	Il fegato dei Molluschi e le sue funzioni. Mitth. Zool. Station, Neapel, 15 Bd.
V. Ariola . . .	La pseudogamia osmotica nel Dentalium entalis. *Ibid.*
F. S. Monticelli and S. Lo Bianco	Communicazioni sui Peneidi del Golfo di Napoli. Monitore Zoologico Italiano, Anno XII.
F. S. Monticelli . .	Uova e larve di Solenocera siphonocera. Phil. *Ibid.*
L Doncaster . . .	Notes on the development of Sagitta. Proc. Cambridge Phil. Soc., vol. 11.

IV.—*A List of the Publications of the Zoological Station during the year ending June* 30, 1902.

1. 'Fauna und Flora des Golfes von Neapel,' monograph List, Mytilidæ, to be published in the autumn, 1902.
2. 'Mittheilungen aus der zoologischen Station zu Neapel.' Vol. xv. parts 1 to 3, with 19 plates.
3. 'Zoologischer Jahresbericht' for 1900.
4. 'Guide to the Aquarium.' A new English edition has been published.

Investigations made at the Marine Biological Laboratory, Plymouth.—Report of the Committee, consisting of Mr. W. GARSTANG (*Chairman and Secretary*), Dr. E. RAY LANKESTER, Professor SYDNEY H. VINES, Mr. A. SEDGWICK, *and* Professor W. F. R. WELDON. (*Drawn up by the Secretary.*)

THE British Association's table at the Plymouth Laboratory has been allotted during the past year to the following naturalists :—

Mr. H. M. Woodcock, B.Sc. Lond. (University Scholar), for an investigation of the Life-history of Sporozoa (one month) ; and to

Mr. G. W. Smith, New College, Oxford, for an investigation of the Anatomy of certain Tunicata (three weeks).

The applications received for the use of the table have exceeded the limit placed upon the Committee's powers of appointment by the funds at their disposal. The Committee therefore invite reappointment, together with a grant sufficient to maintain a table at the laboratory for a period of six months (30*l.*), in order to enable Mr. Woodcock to continue his investigations of the Life-history of Sporozoa, to enable Mr. G. W. Smith to begin an investigation of the Sense-organs of Fishes, to enable Mr. W. Wallace, of St. Andrews University, to investigate the variation of the fins in Elasmobranch fishes, and to enable other competent naturalists to perform definite pieces of work at the Plymouth Laboratory.

Mr. Smith will occupy the table during July.

Mr. Woodcock's Report is appended below.

Mr. Woodcock's Report.

I occupied the British Association's table for one month in April and May 1902. My particular objects were two. One was to further investigate some curious bodies which I had noticed attached to the inner side of the mantle—near the apex of the flap—in *Pecten opercularis*, and also attached to a gill filament of the same specimen. The other was to find further stages in the life-history of *Gregarina irregularis*, occurring in the blood-vessels of *Holothuria nigra* at Plymouth.

In most of the *Holothuria* which I had the opportunity of examining, the gregarine was present. In about six instances I found it in the cavity of the blood-vessels, motionless, but easily movable on gently pressing. It was not easy to get them out of a blood-vessel unchanged in shape, for the least touch seemed to distort or make them irregular. Those that were safely liberated were regular in shape, though not uniform. Some would be broader and shorter, others longer and narrower, but all more or less oval in outline.

Observed living, they were white and opaque, but when stained and cleared they all showed two vesicular nuclei, separated by a distinct septum.

The other stage, largely preponderating in numbers, in which I found the gregarines was as little white vesicles attached to the blood-vessel by thin stalks. These vesicles, as already described by Professor Minchin,[1] consist of the evaginated wall of the vessel, containing the rounded gregarine, surrounding which can be easily seen the epithelium of the vessel.

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[1] *Q.J.M.S.*, vol. xxxiv. 1893, p. 279.

All mine at this time had still very few nuclei—in many cases only two, though the septum had disappeared—but in three or four cases they had three nuclei, all of about equal size, and no sign of a fourth. It was evidently rather early in the year for sporulation stages.

That nuclear division may go on before evagination of the vessel's wall I have found by cutting the two gregarines figured whole in the paper above referred to. For in one of them there were eight nuclei, and still traces of a septum; in the other very many nuclei, with no longer a septum; in both cases the nuclei consist of aggregations of chromatin without any membrane.

In no case have I yet found many nuclei. It would be necessary to obtain the gregarines later on in June and July to observe sporoblasts, &c.

For that reason I cannot now present a more detailed account, but hope to obtain further stages in the future.

With regard to the bodies in *Pecten opercularis*, I found them frequently in some batches, while from others they would be absent. This was probably connected with the different localities from which they were dredged by the trawlers. They also occurred in a few *Pecten maximus*, but not in one or two oysters I examined, nor in any other of the many Lamellibranchs I looked at. They occurred invariably on the gills and never once on the mantle-flap again, which was rather contrary to expectation.

But until I have further examined them, and feel more certain as to what they are, I will withhold a description of them.

Investigations in the Laboratory of the Marine Biological Association of the West of Scotland at Millport.—Report of the Committee, consisting of Sir JOHN MURRAY (*Chairman*), Dr. J. F. GEMMILL (*Secretary*), Professors BOWER, COSSAR, EWART, W. A. HERDMAN, *and* M. LAURIE, *and* Messrs. ALEX. SOMERVILLE *and* J. A. TODD.

THE Committee have to report that they allotted 15*l.* of the grant to Dr. James Rankin for an investigation of the Compound Ascidians of the Clyde area, and 10*l.* to Mr. Alex. Patience and Mr. Thomas Scott, F.L.S., for an investigation of the Crustacea of the Northern Clyde lochs.

Mr. Patience obtained through his grant the use of the s.y. 'Mermaid' belonging to the Millport Marine Station for twelve days in May and July 1902. He took in all fifty-five hauls with the dredge and trawl, chiefly in Loch Fyne, Loch Long, Gareloch, and Loch Goil. His interim report to the Committee makes mention of two new Bopyrids—*Pleurocrypta patiencei* (Scott), and *Pleurocrypta cluthæ* (Scott)—found by him and described by Mr. Thomas Scott in the 'Annals and Magazine of Natural History.' His report jointly with Mr. Scott also contained many details regarding the distribution of the smaller Crustacea in the Clyde lochs, but it will be presented to the Committee again when finished.

Dr. James Rankin, as a result of his Ascidian investigation, reports that he has three papers in hand, viz. (1) Second Report on the Tunicata of Millport and neighbourhood, including description of *Polycarpa cinerea*,

n. sp.; (2) *Didemnum punctatum*, n. sp., with observations on the Lateral Languets and the Extension of the Colony; (3) *Protobotryllus tenuis*, nov. gen. et sp., an ancestral form of the Botryllidæ.

As Dr. Rankin has not yet expended all his grant, and as he proposes to devote the rest of it to dredging in the Clyde area in connection with his investigation, the Committee recommend this, and accordingly they ask to be reappointed for next year.

Bird Migration in Great Britain and Ireland.—Fifth Interim Report of the Committee, consisting of Professor NEWTON (*Chairman*), Rev. E. P. KNUBLEY (*Secretary*), Mr. JOHN A. HARVIE-BROWN, Mr. R. M. BARRINGTON, Mr. A. H. EVANS, *and* Dr. H. O. FORBES, *appointed to work out the details of the Observations on the Migration of Birds at Lighthouses and Lightships*, 1880–1887.

ONCE more your Committee have the satisfaction of reporting that, thanks to the unremitting energy of Mr. William Eagle Clarke, the work with which they were charged has proceeded without interruption during the past twelve months, and they append a report to them by Mr. Clarke, in which he has summarised the Observations on the Migrations of the Fieldfare (*Turdus pilaris*) and Lapwing (*Vanellus vulgaris*) in the same masterly manner as he did those relating to the four species (Song Thrush, White Wagtail, Skylark, and Swallow) whose movements he has already worked out. If the Summaries now offered seem to lack interest, it is assuredly only in comparison with those that have been presented before, and because the migrations, inter-migrations, and counter-migrations, even of the Lapwing, however intricate they may at first sight appear, make no approach in complication to those of the Song Thrush, and still more of the Skylark, while those of the Fieldfare may be said to be simplicity itself. Yet the movements of the last-named bird have never before been traced in the way that they have by Mr. Clarke.

It is with great pleasure that your Committee have to report that Mr. Clarke is willing to continue his investigations for another year, if the Association should think fit to encourage his labours, the amount and value of which can hardly be exaggerated; and, though it is hardly part of their business to do so, your Committee cannot refrain from commenting to the Association upon an instance of extraordinary devotion to the subject of the inquiry displayed last autumn by that gentleman. Having sought and obtained the permission of the Elder Brethren of the Trinity House, he passed a month of his short holiday in the Eddystone Lighthouse, in order that he might gain personal experience of the conditions under which nearly all the recorded observations dealt with by him were made, and knowledge of many details of migration only to be obtained by actual observation. It is gratifying to know that in both respects he was successful, as may be seen by the interesting narrative of his voluntary imprisonment which he has published.[1]

Your Committee regarded their reappointment at the Glasgow meeting as a condonation of their somewhat irregular proceeding, acknowledged in their last Report, and are happy to be able to state that valuable information has been received from various lighthouses and lightships on the South Coast of England, the men as before taking very great interest in the inquiry, and returning with excellent results the schedules furnished to them. Encouraged by this success, schedules have again been sent out for the present year. Your Committee respectfully request to be again reappointed, if possible, with a renewed grant of money.

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[1] *The Ibis*, March 1902, pp. 246–269.

Report by MR. CLARKE.

During the past year much advance has been made with the histories of the migrations undertaken by certain species of British birds, and those relating to the Fieldfare and the Lapwing are herewith submitted to the Committee.

In addition to the various sources of information laid under contribution in their preparation, and mentioned in previous reports, much valuable and highly desirable material has been obtained from the Light-stations on and off the south coast of England, thanks to the obliging assiduity of the light-keepers, who have furnished numerous and excellent schedules, many of them replete with useful observations, and in not a few cases accompanied by wings of specimens they were unable to identify.

In September and October last I spent a month in the Eddystone Lighthouse, and added much to the practical experience I had previously gained at various land stations around our coasts.

THE MIGRATIONS OF THE FIELDFARE (*Turdus pilaris*).

The home of the Fieldfares which visit the British Islands is in Norway or Sweden, the former presumably for the most part. The species does not breed in Iceland as the Redwing (*Turdus iliacus*) does, and there is no evidence to show that any of the small colonies established in various parts of Central Europe (Pomerania, Thuringia, and Bavaria) ever contribute to the throng that arrives on our shores.

The British migrations of this species may be taken as being generally typical of those of (1) a winter visitor to our islands from North-western Europe, and (2) of a bird of passage *en route* from and to its northern summer home and winter quarters lying to the south of the British Isles. In addition, British winter movements (due to the pressure of climatic conditions) and emigration beyond our shores are performed annually.

Autumn Immigration.—The Fieldfare seldom quits its summer haunts in North-western Europe until October. There are, however, authentic records of the appearance in Great Britain of odd birds, and, more rarely, small parties in September, but such occurrences must be regarded as unusual. With a single exception, the September records relate to the East Coast and its vicinity.[1]

There are annual arrivals of comparatively small numbers in the first half of October. It is not, however, until after the middle of the month that the first of the great autumnal immigrations is to be expected; for the date of the northern exodus is dependent upon the nature of the season, and especially of the crop of berries, in Scandinavia, and, as a rule, this does not drive the birds southwards until the third or fourth week of October. They continue to arrive on our coasts until mid-November, the 19th being the latest date for the years covered by the inquiry.

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[1] The most remarkable of these early immigrations was the occurrence of a large flock near Norwich on September 9, 1880 (T. Southwell).

The following are the dates of the chief immigrations recorded during the years 1880–1887 :—

1880. October 21–28. Latest, November 18.
1881. October 19.
1882. October 15–16, 18–19.
1883. October 19, 28–30. November 1–2, 8.
1884. October 24, 29. November 2, 4, 12.
1885. October 14, 31. November 8, 10–12.
1886. October 28, 29.
1887. October 26.

It will be observed that in some seasons the birds mainly arrived by a series of pronounced movements, while in others a single 'rush' only is chronicled. When the latter was the case it was preceded or followed (or both) by a steady influx, covering the ordinary period of the autumnal incoming. On many occasions these great immigrations cover the eastern seaboard from Unst, in the Shetland Isles, to, or even beyond, the Wash.

After arrival the immigrants quickly find their way to accustomed winter quarters, including those in the western districts.

A migratory stream of Fieldfares, though one of much less extent, passes down the west coast of Scotland, and is chiefly observed in the Western Isles, where it comes much under observation at the rock-stations of Skerryvore and Dhuheartach, and sometimes extends as far to the west as the Monach group. The Outer Hebridean branch of this stream reaches the north coast of Ireland, whence many of the birds proceed inland to winter quarters. Regarding these western movements it must be observed that (1) they are not performed simultaneously with those on the east coast, and the birds probably reach and pass down our Atlantic shores after an overland flight ; (2) it seems probable that the Fieldfares regularly travelling southwards by way of the Outer Hebrides may reach that far western route by way of the Faröes, which islands are visited annually in the autumn[1]—an interesting fact since the bird does not summer in Iceland, and, moreover, one which indicates an astonishing extension westwards of the right wing of the hosts moving southwards on the approach of winter.[2]

Autumn Passage and Emigration.—An autumn passage to winter quarters beyond the British Isles is chiefly observed on our east coast, and immediately follows the immigrations of the latter half of October and the first half of November. Thus many Fieldfares quit our southern shores very shortly after their arrival, and consequently the dates of immigration, passage, and emigration closely correspond. A number of the immigrants observed on the west coast also proceed southwards—some of them along the east coast of Ireland, and thence across St. George's Channel ; others by way of the west coast of England and Wales—and these birds of passage finally quit our shores at points on the western section of the south coast of England, particularly between the Eddystone and the Scilly Isles.

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[1] Mr. Knud Andersen informs me that the Fieldfare occurs on migration in both spring and autumn at the Faröes.

[2] In the *Zoologist* for 1880, p. 510, Mr. Gurney mentions that during October of that year Fieldfares were observed going from east to west at Cromer; and the same authority (*op. cit.*, 1892, p. 61) states that several which had perished on passage were picked up at Yarmouth on November 8, 1901. These records, however, do not necessarily indicate an east-to-west movement across the southern waters of the North Sea on the part of this species.

Winter Movements and Emigration.—On the advent of snow and cold the Fieldfares quit the higher grounds which form their usual winter quarters and seek the lowlands, the coast,[1] and the south.

In seasons of exceptional cold and heavy snow vast numbers pass southwards along our coastlines and overland *en route* for the southern counties, while many cross the Channel for South-west Europe. Many, too, are sometimes observed passing westwards along the south coast of England and its vicinity, in company with Thrushes, Redwings, Blackbirds, Starlings, Larks, Linnets, Lapwings, &c., in search of the milder conditions usually to be found in Devon, Cornwall, and the Scilly Isles. Emigrants from the mainland of Northern Britain then visit the Hebrides; and numbers enter Ireland from Scotland and North Wales; but none of the numerous Fieldfares which sweep along the south coast of England appear to seek the sister isle from the south-east by a passage across St. George's Channel, as do Song Thrushes, Starlings, Larks, and other refugee British species. In Ireland during severe periods many leave their ordinary winter haunts and pass southwards and westwards for the milder areas to be found in the vicinity of the Atlantic.

The time at which these winter movements take place varies according to the nature of the season. In 1886 great cold set in as early as November 22, and was the cause of much migration and an exodus from our southern shores which continued until the 26th. The movements may be local or general, and if a series of cold snaps occurs a corresponding series of migrations results; but should the storm be widespread general emigrations follow.

A small number of Fieldfares winter in Southern Scandinavia, and in severe seasons some of these are probably driven southwards and westwards, and this no doubt accounts for the occasional appearance of small numbers in December in Shetland and Orkney and at the Faroes (Andersen).

Spring Immigration from the South.—Towards the end of March, the Fieldfares which have wintered in countries south of the British Islands (including, no doubt, the winter emigrants driven from Britain) make their appearance on our southern shores. These return passages across the Channel are continued at intervals throughout April, and are sometimes observed down to the early days of May.

During these movements the birds are recorded as arriving at night or in the earliest hours of the morning, and are usually accompanied by Redwings, Thrushes, Blackbirds, Starlings, Wheatears, and other species.

The immigrants which arrive in England during March do not appear to move northwards at once, but sojourn with us for a little time before departing for their summer quarters in Northern Europe.

Spring Passage and Emigration.—The departure of the Fieldfares which have wintered with us, and of the birds of passage on their way northwards, does not commence until the early days of April, and ordinarily lasts until the first week in May, but in some seasons is prolonged until about the middle of that month, while stragglers have been observed as late as the first week in June.

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[1] The appearance of this bird in numbers on the coast in the winter has led some observers to suppose that a renewal of the immigratory movements from Northern Europe has occurred, whereas it is directly associated with and is the result of the weather conditions prevailing in our islands, which have driven the wintering Fieldfares from the inland districts.

The earliest emigrants appear to leave in small parties, either alone or at the same time as Meadow Pipits, Skylarks, Lapwings, and sometimes Bramblings; but those that follow late in April and in May are observed at East Coast stations in great flocks and in company with many other emigrants and transient migrants—*e.g.*, Redwings, Ring-ousels, Wheatears, Whinchats, Redbreasts, Redstarts, Willow Warblers, Blackcaps, Pied Flycatchers, Bramblings, &c.

Some of the great spring emigrations cover considerable sections of the eastern seaboard, having been observed from the Farne Islands to Orkney and Shetland, and from the Wash to the Firth of Forth.

There are also important movements of departure on the west coast of Britain. These are observed somewhat feebly at the English, Welsh, and Manx stations, but become more pronounced on the Scotch Coast (including the Hebrides), which receives the Irish emigrants *en route* for the north. This western passage also sets in during the earliest days of April and lasts until mid-May, but no great general flights are witnessed. There is also much overland migration from the western districts to the east coast performed throughout Great Britain.

Before proceeding to the coast for departure, Fieldfares assemble and form flocks in the various districts in which they have wintered, and are very noisy and restless for several days before they finally quit their winter haunts.

This species is extremely wary, and is less frequently killed or captured at the lanterns of the light stations than any of its congeners.

The Migrations of the Lapwing (*Vanellus vulgaris*).

Introductory.—The migrations of the Lapwing in the British Islands are especially interesting, and possess features which are not shared by any of the species treated of in the reports hitherto presented to the Association.

When we come to investigate the various movements performed by this well-known bird, it is surprising to find how largely they escape notice. This may to some extent be accounted for by the fact that the Lapwing is partially nocturnal in habit, and hence less prone than other species to approach the light-stations; but this does not, I think, afford an entire explanation, for other *Limicolæ* of even more pronounced nocturnal proclivities, such as the Woodcock, do not pass unobserved to a like degree.

In addition to being a resident during the major portion of the year in extensive areas of our islands, the Lapwing is a summer visitor to Shetland, Orkney, and the Hebrides, to the more elevated districts throughout the mainland of Great Britain and Ireland, and to other inland areas, especially in the North.

As winter visitors and birds of passage some numbers arrive on our shores in the autumn from Scandinavia and from Western Central Europe.

The great majority of our British-bred birds and, perhaps, also of the Continental immigrants, pass the cold season in Great Britain and Ireland, but extensive winter movements are performed under the pressure of severe climatic conditions which affect the food-supply. Then many emigrate southwards and westwards, and others cross the Channel to the shores of France.

In addition, many minor or local movements, due to varying weather influences, are performed in both autumn and winter in all parts of our islands resorted to by this bird. Indeed, almost every change in the weather results in some shifting of quarters at these seasons.

Our native Lapwings are widely distributed and extremely numerous, and there can be little doubt that they form the great majority of the individuals which participate in the many and various migratory movements undertaken by this species at different seasons both within and on our shores.

Except the winter movements, when forced and sometimes general retreats have to be undertaken, the migrations of the Lapwing are very gradually performed and cover an extended period in each season, but no general flights simultaneously performed on all or any section of our coasts have been recorded.

British Summer and Autumn Movements.—At the close of the nesting season Lapwings, old and young, gather together and form flocks. As early as mid-June or during July small parties, even flocks, sometimes appear in the vicinity of the coast, and occasionally a few are recorded as visiting the islands, or as appearing at the rock-stations and lightships off the east and west coasts of Britain. Such movements are not without interest, but as a rule it can scarcely be claimed for them that they possess any direct bearing upon the ordinary migrations of the bird. During some seasons, however, movements southward have been recorded in July;[1] but these must be regarded as exceptional, and probably due to the disturbing influence of local meteorological conditions.

In August emigration from Shetland commences, and the majority of the birds leave during the month. The records of Lapwings at the coast stations and at the off-lying lighthouses and lightships[2] are numerous though uncertain, and indicate that movements or wanderings are in progress.

In September the migration southwards sets in in earnest. Early in the month those which have summered in Shetland, Orkney, and the Hebrides continue or begin to emigrate, and by the middle of the month or before, all, save a few stragglers, have departed from the northern group. Many, too, quit the higher ground on the mainland, especially in Scotland. These decided emigrations result in passage movements southwards or towards the shore which are chiefly in evidence on both the coasts of Scotland and that of the North of England.

During October the autumnal movements of the Lapwing reach their maximum. The higher breeding-grounds are then entirely deserted for the cold season, and much emigration is also in progress from the northern and other inland districts and from the Hebrides to accustomed winter quarters, such as lowlands in the vicinity of the coast—especially near estuaries—and the southern counties generally, including the Scilly Isles, which are annually resorted to from October onwards. Many, however, remain during mild winters in suitable haunts in Northern Scotland, as in the neighbourhood of the Beauly and Moray Firths, where the climatic conditions are exceptionally favourable. The British October migrants are observed on all sections of the coast, and the passage movements southwards are no doubt augmented by the presence of immigrants from Northern Europe.

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[1] The chief of these was observed at the Leman and Ower Lightship (twenty-five miles N.E. of Cromer) on July 30, 1887, when, during unsettled weather, a great flock passed southwards at 3 P.M. On July 2, 1901, after a strong N.E. wind and dirty weather, Mr. S. Southwell saw on a Lowestoft trawler two which had been captured out of a large flock about forty miles N.E. of that port.

[2] At the Seven Stones Lightship (seven miles off the Land's End) on August 26, 1880, about fifty Lapwings were observed flying south-west in the direction of the Scilly Isles at 10 A.M.

The movements during the first half of November are a continuation of those of the previous month. By about the middle of the month the birds have usually settled down for the winter, or until they are compelled to move by the pressure of adverse weather and its effect on their food-supplies. A small number remain in the Hebrides until the first onset of frost.

Although a few records, both Scotch and Irish, point to some immigration into Ireland from Northern Britain in September, it is not until October and November that such movements are regularly observed. The main lines of intermigration lie between the Mull of Cantyre and the Solway, and the coasts of Antrim and Down; while birds quitting or traversing the Hebrides reach the shores of Donegal, some of them by way of Tory Island. During October and November, too, there is some evidence of the arrival of Lapwings in Ireland from the south-east by a passage, chiefly observed during the daytime, across St. George's Channel to the Wexford and adjacent coasts. Certain of the later November immigrations from the north are associated with the setting in of more or less severe weather in Scotland.

The autumnal movements of the Lapwing are mainly undertaken during the night, but it is only occasionally that the migrants strike the lanterns of the lighthouses and lightships. Not a few are seen moving during the daytime, while others are observed in the vicinity of the mainland stations, or on islands, resting after their over-night flight.

Autumn Immigration from North-western Europe.—The autumn immigration from Scandinavia[1] sets in during the first week of October and lasts a little over a month. It is observed at stations from and including Shetland to those on the northern section of the east coast of England. No great arrivals covering extensive portions of the coast line have been recorded, as in the case of other species, but only scattered records dealing with moderate numbers appearing at intervals. At the northern islands, where the birds arrive some considerable time after the summer visitors have departed, their appearance is irregular during October and November; in some seasons they occur in fair numbers, while in others they are very scarce. It is doubtful if we derive any very great numbers from Northern Europe, as that portion of Norway from which the British Isles presumably receives immigrant Lapwings affords only somewhat limited haunts for this bird as a summer visitor.

The northern immigrants arrive on our shores during the latest hours of the night and the earliest of the morning, and frequently appear simultaneously, if not in company, with Song Thrushes, Fieldfares, Redwings, Blackbirds, Ring-ousels, Redbreasts, Goldcrests, Bramblings, Skylarks, Starlings, Snipes, Woodcocks, &c.

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[1] The Lapwing is only a rare straggler to Iceland, but occurs on passage in small numbers during both spring and autumn, in most years, at the Faröes (Andersen).

Autumn Immigration from the East.—During October and early November[1] there are records of parties of Lapwings being observed at the lightships off the south-east coast of England between the mouth of the Thames and the Wash and Humber, proceeding from the E. and S.E. in a W. and N.W. direction, which leave little doubt that immigrants from the Continent arrive on our shores by a direct passage across the southern waters of the North Sea. The arrivals take place during the daytime and at night; but there are no general movements recorded at the light-stations, and the observations chronicled are few and scattered during any season, though the numbers recorded are occasionally considerable.

Mr. Caton Haigh informs me that the normal course of the Lapwing arriving on the N.E. coast of Lincolnshire is from S.E. to N.W., and Mr. Gurney has occasionally observed them coming in on the Norfolk coast from the E. and S.E.

Autumn Passage of Immigrants.—Beyond passing partially down coast lines, chiefly the east, and overland to reach their winter resorts in Britain, it is uncertain whether the immigrant Lapwings perform other passage movements on arriving on our shores in October. If such transient migrations southward to countries beyond the British seas do take place immediately, or soon, after Britain is reached—as is undoubtedly the case with other species—then they have hitherto escaped notice at the southern stations.

Autumn Emigration from Britain.—Our native Lapwings and the autumnal visitors from the Continent seem loth to quit our shores. I have not been able to find any evidence of emigration beyond British limits for the months of September and October, though the movements southward during the latter month would lead one to expect that some of the birds then depart from Britain.

No Lapwings have been detected, according to our data, crossing the Channel before November, when no doubt the approach of winter, especially low temperatures, constrains some of them to seek more genial climes. During this month they have been recorded as leaving our southern shores in considerable numbers at night in company with Mistle Thrushes, Song Thrushes, Fieldfares, Redwings, Blackbirds, Starlings, Larks, Golden Plovers, and others. Some of these cross-Channel emigrations are associated with general movements of Lapwings and other species down both the east and west coasts of England.

Winter Movements and Emigration.—The winter movements of the Lapwing consist of emigrations from Britain for more southern lands, and of partial or extensive migrations performed within our area.

They are controlled by and vary with the climatic conditions of the season, and their extent is proportional to its severity.

Should the late autumn and the winter prove mild, the Lapwings remain unmolested, so to speak, in their accustomed retreats. Sooner or later, however, each winter cold weather of a more or less severe type, and of either local or general prevalence, sets in, and then the birds, owing to their inability to obtain food are compelled to change their quarters for others free from its blighting influence: these havens may be near at hand or far removed in accordance with the extent of the area adversely affected. Heavy snow and severe frost cause great movements southwards along the coasts and overland. Should such conditions extend to the South of England much emigration is embarked upon for the shores of France, great numbers of Lapwings crossing the Channel both by day and night. Occasionally during these periods of exceptional severity many of these birds, along with other species affected ('Thrushes,' Larks, Starlings, &c.), are observed moving westwards during the daytime along the south coast of England and its vicinity *en route* for Devon, Cornwall, and the Scilly Isles, and not a few then cross St. George's Channel to Ireland,[1] where milder conditions usually prevail. In the Sister Isle the counties of Cork and Kerry are largely resorted to by the Irish birds when in distress. There appear to be no winter movements westward to the Hebrides as in the case of several other species affected by severe weather on the mainland.

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[1] In 1885 at the Hasbro Lightship, off the Norfolk coast, many were passing W. and W.N.W. on the nights of November 22 and 23 perhaps a cold weather movement from the Continent.

The time when the winter emigrations from Britain may be enforced varies greatly. Thus during the season 1901-1902 the weather in the South of England remained mild until February, when it became exceptionally severe, and continued so for a long time. At the Eddystone and elsewhere on the South Coast no Lapwings had been observed crossing the Channel previously during the winter, but on February 2, and again on the 13th and 15th, great numbers passed southwards both by day and by night. Winter movements within our isles have been recorded as late as mid-March; on the 15th, in 1881, many Lapwings, along with Skylarks, Starlings, Golden Plovers, Woodcocks, and Snipes, were observed flying southwards before snow at the Nash Lighthouse, on the north shore of the Bristol Channel.

It is when retreating before these adverse conditions that the movements of the Lapwing become pronounced and widespread, and, in this respect, contrast markedly with the other migrations of this species. It is on such occasions, too, that the bird chiefly approaches the lanterns and is killed or captured, a fate which does not commonly befall it.[2] On the night of December 17, 1885, twenty-one were captured at the Eddystone out of several hundreds which appeared at the light—the record for the period 1880-1887. Comparatively few perish by starvation, even in winters of exceptional severity.

Winter Immigration from Western Central Europe.—During severe winters on the Continent the east-to-west passage of Lapwings across the southern waters of the North Sea is renewed. The immigrants, as in the autumn, arrive on the south-east coast of England and pass westward in search of the milder areas within our isles.[3]

Spring Movements from British Winter to Summer Haunts.—To their breeding grounds in England and the south of Scotland Lapwings may be induced by the prevalence of mild weather to return in small parties as early as the end of January and beginning of February, but are usually compelled to retreat by the advent or recurrence of severe climatic conditions. The usual period for their appearance in their summer haunts is about the last week in February and early in March, and should severe weather follow later in March, then many perish in the more exposed areas. The Scilly Isles are quitted as a winter resort by the middle of February in ordinary seasons.

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[1] Occasionally during severe winters numbers of Lapwings have been observed passing westwards at stations off and on the east coast of Ireland, which points to a passage of emigrants from North Wales.

[2] In sixteen years eight only were obtained at the Irish light-stations; and Mr. Herluf Winge informs me that twenty-one were killed at the Danish stations during a like period.

[3] At Great Yarmouth on December 22, 1894, hundreds of Lapwings were observed 'coming over' against a strong N.W. gale, and many were drowned (*Zoologist*, 1900, p. 163).

Immigrants occasionally appear in Orkney at the end of February, but this is exceptional, for the summer visitors to these islands do not usually arrive before March, and in some seasons the date of their first appearance is not chronicled until the early days of April. The return to Shetland is usually timed from mid-March onwards; but immigratory flocks have been recorded as early as March 3, and the Hebrides are sought during late February and early March. The spring movement is a gradual one, and nothing of a general nature is observed.

Spring Immigration from Southern Europe.—The return of the Lapwings which departed from our islands in the autumn and winter only occasionally comes under notice at the light-stations and elsewhere on the south coast of England. Fortunately, however, we possess some important records of these spring immigrations for the latter half of March, when the Lapwings have been observed returning in company with Wheatears, Mistle Thrushes, Fieldfares, Blackbirds, Starlings, and other species. The chief of these cross-Channel return movements were witnessed during the earliest hours of the morning.

Spring Return to Ireland.—Late in February, during March, and sometimes early in April, Lapwings are observed during the daytime arriving from the S.E. and passing N.W. at the light-stations off the Wexford coast. There is no special reason for regarding these as passage movements, and, taken together with the facts, (1) that they are not observed proceeding up the eastern coast line northwards, and (2) that during winter Lapwings are recorded as passing southwards on the extreme southern sections of both coast lines, it is not improbable that some of these birds quit Ireland under the pressure of climatic conditions and return in the spring.

Spring Passage Northward and Emigration to Northern Europe.—The spring passage northward to British and Continental breeding haunts is one of the best observed phases in the ordinary seasonal migrations of the Lapwing. It is witnessed on both the east and west coasts and in the northern islands.

In some years a few are seen, even at northern stations, on passage at the end of February, and many have occasionally been observed during the latter half of the month and at the beginning of March, but these early transient migrations are dependent upon the genial nature of the season. The movements are regularly observed during March and are much in evidence until about mid-April, after which stragglers only are observed.[1]

The numbers observed *en route* are only occasionally described as being considerable, and, as a rule, consist of flocks or small parties, observed at widely scattered stations, there being no general or simultaneously performed movements.

These birds of passage move during the night, and in the daytime may be seen at various points on the coast and the off-lying islands—the Farnes, Isle of May, and the Pentland Skerries on the east, and the Isle of Man, Dhuheatach, Skerryvore, Sule Skerry, and even the remote Flannans, on the west—and at the various isles of the Orkney and Shetland groups. A number proceed overland in various directions to reach the coast.

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[1] On May 3, 1885, a great rush of birds of passage was observed at the Isle of May, at the mouth of the Firth of Forth. The species recorded included Fieldfares, Redwings, Ring-ousels, Blackbirds, Pipits, Redbreasts, Whinchats, Redstarts, Pied Flycatchers, Ortolan Bunting, and some Lapwings.

The emigrants for North-west Europe mainly move along the east coast, and many cross the North Sea ere the Orkneys and Shetlands are reached, though some numbers visit these islands regularly on passage to their Scandinavian summer quarters.

The Lapwings which have wintered in Ireland begin to move northward, in mild seasons, about the middle of February; but the chief emigrations take place during March, after which month they fall off, though some have been observed in the end of April. The latter, however, are exceptional occurrences. The emigrants mainly depart from the north-east coast and proceed in various directions towards Scotland: these are chiefly observed during the daytime. There is also a return migration to the south-east from the Wexford and adjacent coasts late in February, but this, like most emigratory movements, largely escapes notice, and our data regarding it are only slight.

No return migrations of Lapwings from our south-eastern shores to Western Central Europe by a west-to-east passage across the southern waters of the North Sea have been detected. But when we call to mind the difficulty of making observations and the general obscurities that surround the nocturnal emigratory movements this is not very surprising.

Index Generum et Specierum Animalium.—Report of the Committee, consisting of Dr. H. WOODWARD (*Chairman*), Dr. F. A. BATHER (*Secretary*), Dr. P. L. SCLATER, Rev. T. R. R. STEBBING, Mr. R. MCLACHLAN, *and* Mr. W. E. HOYLE.

THE Committee beg to report that the first section of Volume I. of the 'Index,' dealing with the period 1758–1800, has been printed off. The volume will be completed by a list of all the specific names indexed under the generic names with which they are associated. This part of the work is rapidly approaching completion, and it is expected that the volume will be issued in October this year, as already announced. It will consist of about 1,300 pages in post 8vo, and will be published by the Cambridge University Press, at a price of 25*s*. to those who subscribe before the day of publication.

The energies of Mr. C. Davies Sherborn have naturally been fully absorbed in passing these sheets through the press; but work on future volumes, which has never been wholly laid aside, will now be taken up again in earnest. The Committee therefore earnestly request to be reappointed and to have a renewal of the grant of 100*l*., without which this highly important work cannot be carried on.

Coral Reefs of the Indian Region.—Third Report of the Committee, consisting of Mr. A. SEDGWICK (*Chairman*), Professor J. GRAHAM KERR (*Secretary*), Professor J. W. JUDD, Mr. J. J. LISTER, Mr. FRANCIS DARWIN, Dr. S. F. HARMER, *and* Professors A. MACALISTER, W. A. HERDMAN, *and* S. J. HICKSON, *appointed to investigate the Structure, Formation, and Growth of the Coral Reefs of the Indian Region.*

THE Committee have received the following report from Mr. J. Stanley Gardiner:—

During the greater part of the year I have been engaged in working up the Coral Formations of the Maldive and Laccadive Archipelagoes. Most of the collections of animals also have now been sent out to various specialists, and are awaiting identification.

The results of the expedition are being published in a series of demy quarto parts by the Cambridge University Press, under the title of 'The Fauna and Geography of the Maldive and Laccadive Archipelagoes.'

Parts 1 and 2 of Volume I. have been issued, and contain a short account of the expedition, and Chapters I.–VII. of my Report on the Coral Formations, besides the following special reports: 'Hymenoptera,' by P. Cameron; 'Land Crustaceans,' by L. A. Borradaile; 'Nemerteans,' by R. C. Punnett; 'Amphibia and Reptilia,' by F. F. Laidlaw; 'Lepidoptera,' by Ed. Meyrick; 'Echiuroidea,' by A. E. Shipley; 'Sipunculoidea,' by A. E. Shipley; 'Land and Freshwater Mollusca,' by Edgar A. Smith; 'Pigments of Corals,' by C. A. MacMunn; 'Crustaceans (Varieties and Portunidae)' by L. A. Borradaile; 'Chaetognatha,' by L. Doncaster, and 'Dragon Flies,' by F. F. Laidlaw.

Reports have also been received on the Actinogonidiate Echinoderms, the Dredged and Freshwater Fish, Orthoptera, Crustaceans (Xanthidae), Turbellaria, Earthworms, Birds, Cephalochorda, and Nudibranchiata, and will shortly be published.

'The Botany of the Maldive Islands' has been exhaustively dealt with by Mr. J. C. Willis and myself in the 'Annals of the Royal Botanic Gardens, Peredeniya,' vol. i., part 2.

The Committee desire reappointment.

The Zoology of the Sandwich Islands.—Twelfth Report of the Committee, consisting of Professor A. NEWTON (*Chairman*), Mr. DAVID SHARP (*Secretary*), Dr. W. T. BLANFORD, Professor S. J. HICKSON, Dr. P. L. SCLATER, Dr. F. DU CANE GODMAN, *and* Mr. EDGAR A. SMITH.

THIS Committee was appointed in 1890, and has been since annually reappointed. Last year a grant from the Association was asked for by the Committee, but was not accorded. The Committee were consequently for a time without the funds necessary to enable them to retain the services of Mr. Perkins, on whom they relied to complete the working out of the extensive collections.

Last June the Committee received for its work a grant of 200*l.*

from the Government Grant Committee of the Royal Society. In the meantime Mr. Perkins had accepted an appointment in the Sandwich Islands, and there is now little prospect of his speedy return to England. As a consequence work has been suspended to a considerable extent. Mr. Perkins has, however, been so kind as to draw up an account of the Birds; and the working out of the Diptera has been completed by Mr. Grimshaw and Dr. Speiser. The Hemiptera have been finished by Mr. Kirkaldy, and it is anticipated that the supplement to Lepidoptera, by Mr. Meyrick, as well as the Micro-lepidoptera by Lord Walsingham, will shortly be ready for publication.

The Committee ask for reappointment, with a grant of £50.

Terrestrial Surface-waves and Wave-like Surfaces.—Second Report of the Committee, consisting of Dr. J. SCOTT KELTIE (*Chairman*), Dr. VAUGHAN CORNISH (*Secretary*), Lieut.-Col. BAILEY, Mr. E. A. FLOYER, *and* Mr. W. H. WHEELER. (*Drawn up by the Secretary.*)

SINCE the Glasgow meeting the observations upon drifting snow made in Canada during 1900–1901 have been worked up, and the principal results published in the 'Geographical Journal' for August 1902 in a paper upon Snow Waves and Snow Drifts in Canada, with notes upon the Snow 'Mushrooms' of the Selkirk Mountains.

In this paper the forms of stationary snowdrifts (or sandhills) formed in the neighbourhood of fixed obstructions are for the first time brought into harmonious relationship with the forms of travelling snowdrifts (or sandhills). The former, when completed by the supply of sufficient material to fill in the whole of the eddy space, are *ichthyomorphic* structures of easy lines, with a fine 'run' and relatively bluff 'entrance' to windward.

In the travelling drifts, or waves, on the other hand, the eddy space on the lee side is never filled up, as it continually moves forward (which is the wave motion), and the form maintains the fine entrance and blunt stern which is the aspect of greater eddy-making resistance.

The observed shapes of incomplete snowdrifts (and sandhills) are numerous, but it is believed that all are circumscribed by the assigned ichthyomorphic boundary, the lines of which are finer in the case of snow than in that of sand.

Progress has been made in the examination of measurements of deep sea waves by different observers. It is found that the records of the velocity of ocean swells, observed after storms, have acquired a new interest from the recent reduction of about 25 per cent. in the factor used by meteorologists for calculating the velocity of wind from the records of the cup anemometer. Employing the newer values, it appears that the velocity of the longest observed oceanic swells in European waters is but little less than the greatest hourly velocity of wind reliably recorded on our coasts.

An extended table of the heights of deep-sea waves as related to the velocity of the wind has been drawn up, in which it is found that when the scales of estimated wind force expressed by conventional numbers are reduced to a common standard, and the newer equivalent velocities applied throughout, fairly concordant results are obtained for observations by different observers made during different years from different ships.

Observations have been made of the tidal bore in the River Severn, of which a successful cinematograph picture was obtained at Stonebench near Gloucester, which has been described in the 'Geographical Journal' for January 1902 ('Cinematographing the Severn Bore'). Observations of the bore have been made at other places on this river, and it is proposed to continue these, and to make similar observations on the River Trent.

The pictorial record of terrestrial surface waves and wave-like surfaces has been extended by new photographs of the Severn bore at different stages, breakers in a storm, wave track of ship-models at the Admiralty Experiment Works, Haslar; the wave track of a torpedo-boat destroyer, &c., and observations and photographs have been made of the movements of mud streams, which will be reported upon later.

The grant has been expended, and the Committee ask for reappointment, with a grant of 25*l*.

Women's Labour.—Second Report of the Committee, consisting of Mr. E. W. BRABROOK (*Chairman*), Mr. A. L. BOWLEY (*Secretary*), Dr. CHARLES BOOTH, Professor S. J. CHAPMAN, Miss C. E. COLLET, Professor F. Y. EDGEWORTH, Professor A. W. FLUX, Mrs. J. R. MACDONALD, Mr. L. L. PRICE, *and* Professor W. SMART, *appointed to investigate the Economic Effect of Legislation regulating Women's Labour.*

APPENDIX PAGE
I. *Report on the Cotton Industry of Lancashire. By* Professor S. J. CHAPMAN . . . 287
II. *Report on the West Riding of Yorkshire. By* Mr. A. L. BOWLEY . . 291
III. *Report on Birmingham. By* Miss B. L. HUTCHINS 296
IV. *Report on the Boot and Shoe Trades of Bristol and Kingswood. By* Mr. G. H WOOD . . . 299
V. *On Leicester and Northampton. Compiled from Report by* Mr. R. HALSTEAD . . . 304
VI. *On Canning Town and the Isle of Dogs. Abstract of Report by* Miss HADLEY . . . 305
VII. *Switzerland: Federal Legislation—Cantonal Legislation* . . . 306
VIII. *Holland* . . . 308
IX. *Grand Duchy of Luxembourg* . . . 309
X. *Hungary* . . . 309
XI. *Finland* . . . 310
XII. *Russia* . . . 310
XIII. *Sweden* . . . 310
XIV. *Norway* . . . 310
XV. *Denmark* . . . 311

THE Committee had associated with them in their work Miss A. M. Anderson, Miss Helen Blackburn, Professor George Adam Smith, D.D., and Mrs. H. J. Tennant.

They have received reports from investigators in several of the districts where women are largely employed.[1] The results obtained from the

[1] The investigators were requested to observe the following points:

I. The effects of the legislation *generally*:—

reports are contained in Appendices I. to IX. The Committee present these results as instalments of opinions and information received by them bearing upon the questions referred to them, but must not be understood to have adopted any of the conclusions arrived at by the investigators, or to present them as the opinion of the Committee.

Reports having reference to the industries of Glasgow and other parts of Scotland have been received, but they are reserved for a future report, as some of the questions involved have given rise to discussion, and it is desirable that fuller information should be obtained.

It should be observed that all the subjoined statements relate to a time previous to January 1, 1902, when the Factories and Workshops Act, 1901, came into operation.

The Committee have also obtained information bearing upon the inquiry from foreign countries, the results of which are set forth in Appendices X. to XV.

For obtaining further information and presenting the general results of the inquiry in a complete form they desire to be reappointed.

I.—*The Economic Effect of Legislation regulating Women's Labour in the Cotton Industry of Lancashire. By* Professor S. J. CHAPMAN.

By the Act of June 6, 1844 (7 Vict., c. 15), all adult females in factories were made subject to the same restrictions as young persons. They were therefore forbidden to work, as a rule, more than sixty-nine hours per week, or twelve hours a day, or to work between the hours of 8.30 P.M. and 5.30 A.M., except in comparatively rare cases. By the Act of 1845 (8 & 9 Vict., c. 29) all-night work by women was strictly forbidden. The Acts had no marked effect on the demand for women, though the number

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(1) Has it necessitated or induced any alteration of custom, or merely enforced what was customary before, in the case of the *women* themselves, in the industry in question, or in others related thereto?

(2) Has it necessitated any alteration in the case of *other* workers (men, young persons, or children) in the industry in question, or in other industries related thereto?

II. The effects of the legislation *specially*, on the position of women:—

(1) Has it lowered or raised the wages of women (either temporarily or permanently)?

(2) Has it caused any displacement of women?

(3) Has it initiated any important changes in the use of machinery or the division of labour?

(4) Has it increased the efficiency of the women themselves, as industrial agents? And is this efficiency due to all, or only to some, of the legal restrictions?

(5) Has it increased their economic efficiency as members of society (*e.g.*, with relation to home life, the health of the children, the morality of the race), and are these effects due to all, or only some, of the restrictions?

N.B.—The legislation may affect the demand for women's labour:—

(1) Directly, in the industry in question, by adding to difficulties of management, or by diminishing the output of the women themselves, or of others engaged in the work.

(2) Indirectly, by effects on other industries related to the industry in question; or it may increase the supply of women and their substitution for men, by rendering the work healthier or easier.

of children employed in factories began to increase, owing partly to the simpler regulations imposed by the Act of 1844.[1] Indeed, on comparing the years 1833 and 1847, we find that the number of adult women employed in the cotton industry increased faster than the number of adult males. The immunity of women from any special loss was in some degree due to the fact that for a long time previously male operatives had been bitterly opposed to night-work, and that the system of night-work had in consequence been largely discontinued. Moreover, the numbers of women and young persons employed in the cotton industry were so great in comparison with the number of men that factories could not be carried on without them, even for a short time, with any degree of success, and it was not economical to dispense with them entirely. The peculiarity of the effect of the Factory Acts in the cotton industry consists in the circumstance that what is compulsory as regards hours and general conditions for women must be compulsory for all, because the mills cannot run with male operatives alone without the cost of production rising considerably. The following are the particulars as to the classes of people employed in cotton factories in 1847 :—

England	Males	Females
Under 13	10,723	6,814
Between 13 and 18	33,814	47,944
Above 18	78,783	98,950
	123,320	153,708
Scotland		
Under 13	379	366
Between 13 and 18	3,046	8,661
Above 18	5,796	16,868
	9,221	25,895
Ireland		
Under 13	4	11
Between 13 and 18	592	773
Above 18	954	1,849
	1,550	2,633
Total for United Kingdom[2]	134,091	182,236

that is, there were 85,533 adult males to 230,794 women, young persons, and children. In 1870 there were 117,046 adult males to 333,041 protected persons, and in 1896 only 149,146 adult males to 383,774 women, young persons, and children. By the Act of 1847 (10 Vict., c. 29) the hours of young persons and women were reduced at once to eleven a day and sixty-three a week, and after May 1, 1848, to ten a day and fifty-eight a week. Just at first it resulted in attempts to keep the works going the full legal day (from 5.30 A.M. to 8.30 P.M.), with relays of protected persons. The relay systems adopted were complicated and defied the attempts of the factory inspectors to find out whether protected people were being worked longer than the legal hours or not. Hence the Act of 1850 (13 & 14 Vict., c. 54), which did away with this state of affairs by fixing the legal day between 6 A.M. and 6 P.M., or in winter between 7 A.M. and 7 P.M., at the option of the employers. By an unfortunate oversight children were not brought under this statute, so in some few cases male adults and children were set to work outside the legal hours. This was stopped by the Act 16 & 17 Vict., c. 104, which limited the work of children to the legal day. These Acts were not followed by any displacement of women. On the contrary, in the period 1847–70 the number of women and female young persons employed in cotton factories increased faster than the number of adult males. The centesimal proportions of different classes of labour employed in cotton factories were as follows in 1850 and 1875 :—[1]

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[1] Horner's Report, May 1846.

[2] *Parliamentary Papers*, 1847, xlvi. 610–16. (Numbers as in British Museum, MS. paging.)

Children		Male (young persons)		Females of 13 and above		Males of 18 and above	
1850	1875	1850	1875	1850	1875	1850	1875
6·4	14	10·3	8	55·9	54	27·4	24

The effect of this legislation in cutting down the working day for all hands alike was due in large part to the fact that the male operatives wanted shorter hours for themselves, and wanted them because they believed that thereby the demand for labour would be increased. We cannot enter into their views here ; but they certainly fought a battle for short-time for themselves 'behind the women's petticoats.' If an employer tried to dispense with protected persons for certain hours of the day he very soon found that the Act for women and children was intended by the men to be an Act for themselves also. When Leonard Horner, in 1848, questioned 1,153 operatives, male and female, as to their views, 61¾ per cent. declared in favour of the ten hours' day ; out of the 502 women examined only 54¼ per cent. showed themselves to be on the same side.[2]

The next important Act regulating women's labour was that of 1874, the 'Factories (Health of Women, &c.) Bill,' by which a 56½ hours' week was enforced. Though not applicable to male adults, it curtailed their labour also for the reasons given above ; in fact it was openly advocated by the male operatives in their own interests. Again, in consequence, no displacement of women followed ; in the period 1870–78 the number of women and female young persons employed in cotton factories increased faster than the number of adult males.

So far we have been concerned with the question as to whether the Factory Acts affected women prejudicially in any special manner ; now we may pass on to consider whether any of the cotton operatives, male or female, suffered at all, and if so whether the advantages offset the disadvantages. I can find no proof that the product or wages fell appreciably as a result of any of the Acts ; in fact, I cannot but incline to the view that by the Acts on the whole both the product and wages were increased in the long run. Leonard Horner carefully watched for the effects of the Act of 1847, and in 1850 he reported that the daily output under shorter hours was about the same as before, in some cases even with machinery going at the old speeds. It was found, he said, that the operatives were fresher, more careful, and fuller of vitality, and that they could tend without additional strain machinery running at higher speeds. This, observe, was before the full effect of the Act in increasing vitality could have appeared. As to the Act of 1874, its effects were finally reported to be 'trifling and insignificant' as regards wages and the average daily output.[1]

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[1] See Redgrave's Report for April 1875.
[2] Horner's Report for December 1848.

Of course in some respects the legislation specially affecting women could not but affect their earnings occasionally; for instance, the regulation by which they are bound to be absent from the factory for a fixed time after child-birth. This period is now four weeks (having been so fixed by Section 17 of the Factory and Workshop Act, 1891), but in the opinion of many medical men it is highly desirable that it should be extended—some say to three months, and Dr. Tatham has urged to as much as six months. Few people could be found to argue seriously that the regulation curtailing attendance at the mill just after child-birth has not proved beneficial to the mothers, and it is highly probable that women's average earnings over a long period are thereby increased.

With a view to getting suggestions as to the present operation of legislation[2] affecting women's labour and learning the attitude of employers to it, I sent out to many manufacturers and spinners in the chief centres of the cotton industry a circular, of which a portion is given below:—

> 'Would you be good enough to tell us—
>
> (1) Whether the clauses in the Factory Acts relating to women hamper you in any way?
> (2) Whether this legislation has caused a displacement of women or men?
> (3) Whether it has raised or lowered wages?
> (4) Whether it has affected the *efficiency* and *health* of women?
>
> And would you kindly give us in general your opinion of the value or otherwise of legislation regulating women's labour? Would you like it altered or extended in any way?'

The replies received were not sufficiently numerous to enable them to be regarded as typical. However a brief summary of their general tenor will not be without interest. A few employers argued that the industry was made excessively inelastic, so that it became incapable of meeting sudden demands. As regards the second question the answer was invariably that no displacement had been caused. To the third question the answer was in almost every instance that wages had not been affected. Many were agreed that the legislation on the whole had improved health, and, consequently, efficiency, though some thought that parts might be rendered less interfering. One important firm expressed itself as strongly of opinion that the period (now four weeks) after confinement during which women are not allowed to work should be extended.

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[1] Reports, &c., 1876, xvi. 293. See also Reports, &c., 1875, xvi. 317, and 1876, xvi. 301. (Numbers as in British Museum, MS. paging.)

[2] No attempt has been made to estimate the effect of the twelve o'clock Saturday, owing to its recent introduction.

II.—*The West Riding of Yorkshire. Report by* Mr. A. L. Bowley.

The following report is based chiefly on the results of a visit to the chief towns and districts of the West Riding in the summer of 1901, together with some study of reports, pamphlets, and newspapers relating to the textile industries of Yorkshire. Information was obtained from employers in Bradford, Huddersfield, Batley, Leeds, and elsewhere, from the principal trade-unionists connected with the textile industries, from medical officers of health, workpeople, and others. Besides the textile manufacture, the Leeds clothing trade, and the boot trade of the Leeds district were the subject of inquiry.

There have been very few alterations in the laws since 1874 which affect the woollen and worsted industries. The present generation has grown up under the Act of 1874, and it was very seldom possible to get any definite information as to the changes that took place at or before that date. The most profitable plan appeared to be to find out at what points the laws as they now stand are visibly restrictive, and hence to deduce the effects they have had in moulding customs and conditions.

The preliminary question however was, Are the laws carried out? The general impression is that the whole lives of the workpeople are regulated on the basis of the legal hours of labour. There was some hearsay evidence that in one village illegal hours were recently worked with the connivance of the inhabitants; that small workshops in Leeds in some cases escaped inspection, and that work was done beyond legal hours both in the Jewish workshops and in the case of girls in the wholesale tailoring, who are given home-work after being employed in the factory. Minor breaches, on the other hand, appear to be not uncommon. Inspection is rendered more difficult by the thirty days' legalised overtime. In most numbers of the 'Yorkshire Factory Times' there are complaints that in one mill or another time is being cribbed. Working in meal hours is not unknown; though the engine is not running, women are apt, unless prevented, to do odds and ends which will prevent loss of time afterwards. There are also constant and specific complaints that cleaning in motion is necessary to satisfy the overlooker's demands, especially in the carding-room. In Batley cleaning in motion is said to be 'customary, and no one troubles.' The 'particulars' clause seems to fall easily out of effective use in the clothing trade, but it is said to be useful. In the main, however, the laws as to hours are carried out, and the Acts have become more and more effective in workshops, while laundries are now being rapidly brought under supervision.

A special object of inquiry was to find at what points women actually competed with men, and in what cases women worked 56½ hours, while men in the same factory worked a longer or a shorter time.

In the Bradford dyeing trade men worked from 6.0 A.M. to 7.0 P.M. on a full day, the engine running all the time. The few women employed worked ten hours a day and 56½ hours a week with the same engine. When night-work is necessary young men work on the women's machine.

Combing has in comparatively recent times become a women's trade in the day time. In Bradford the women work 56½ hours, while men at night on the same machines work sixty-one to sixty-three hours, the two groups meeting morning and night. Where, however, as at Keighley, master spinners do their own combing, it is customary to run overtime instead of night-shifts, and then men are employed throughout, for it is not worth while to put on a shift of men for a few hours. In other similar cases, however, some of the men carders work at the combs when the women leave, the remainder keeping them supplied. It seems the general opinion that, were the Acts removed, the women, whose work is cheaper, would be driven to overtime and night-work.

When there is great pressure men succeed the girls after hours at fly-spinning in Bradford.

In the card-room the grinders (men) often work overtime.

At Huddersfield men work fifty-nine hours, women 56½, in the same room at the scribbling machines. The feeding machine starts at 6.0 A.M. and runs without stopping till 8.0 or 9.0 P.M. in busy times. The male fettlers leave their proper work to tend it before the women come, after they go, and during meal-times.

At Huddersfield, when night weaving is necessary, and occasionally only for overtime, the men continue the piece that the women have begun. More than one manufacturer in Leeds and Batley has tried night weaving with men, but found that it did not answer.

Spinning is also occasionally done at night in the Huddersfield and Batley district, young men acting as piecers instead of girls.

In Batley it is quite common for men to work overtime on the women's carding machines. They get *5d.* an hour, the women *12s.* for 56½ hours, *i.e.*, 2½*d.* an hour. The men do one-third more work in the same time.

In some factories the men still work the fifty-nine hours general before 1874.

Thus there are many cases where the women work full hours, and are then succeeded by men. On the one hand this indicates that there is an unsatisfied demand for cheaper women's labour; on the other, that the Acts have a very distinct effect in restricting their hours.[1] The general opinion seems to be that the women do not resent this interference, and that, though as individuals they would probably work longer hours if allowed, as a body they would be unwilling to do so.

It is only in special cases that this interchange is possible. I was told that in the Leeds boot trade men and women do not compete; the line of demarcation of work is impassable. In the wholesale clothing factories, pressing is the only work done both by men and women. When there is no necessary line custom may often provide an effective one. The case is, however, often decided by the demand for labour in other industries. Thus in Leeds the men and boys rapidly find employment; hence the piecers are girls and the weavers are women. In Batley the mines have been progressively taking the men from the looms, and the proportion of men weavers is diminishing. In Huddersfield there is still a large number of men weavers. Of all the factors which decide whether women or men shall be employed on a particular machine, it appears to me that the restrictive laws are the least important; the relative expense of the labour of the two sexes, the suitability of the work, local custom, the demand for labour in other industries, all have great influence; but the cases where men are preferred to women, because of the 56½ hours law, are far to seek. I inquired on this point of every one I talked with, and amongst a general body of denial I found only the following exceptions: the case of the woolcombers in the Keighley district, already mentioned; in a Leeds factory it was said that overtime was necessary in pattern-weaving, and hence a very few women perhaps lost work; a prominent member of the Leeds Chamber of Commerce alleged that there were many such cases, but failed to produce details; at Hebden Bridge, in a mill where weaving and the making up of ready-made clothing were carried on in the same building, men weavers were taken in order that they might work the same hours as in the clothing department, but this was a very unusual difficulty.

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[1] It should be remarked in this connection that in the Reading printing and binding trades the ordinary hours are below the legal limit, yet necessary overtime on the women's machines is done by men.

The fact seems to be that the whole industry of the West Riding is accommodated to the laws, and that there is in nearly all districts an equilibrium between the demand for labour of both sexes and all ages and the effective supply; that men could not be obtained for the women's work (at any practicable wage), even if they could do it; and that all efficient women can get work in their respective industries when they are moderately busy.

It is an important but very difficult problem to decide what hours would now be worked in the factories if there were no Acts. The following instances go to show that the hours would be longer: the cases above given where the women stop, but their work is carried on; the attempt of the women to put in extra work at meal times; the frequent cases of overtime worked by men in various parts of the factories; twelve factories in the Batley district where the men still work the old fifty-nine or sixty hours; the longer hours said to be worked by non-regulated home workers. On the other hand we have the following instances of the working of shorter hours than the legal minimum. In the Leeds boot trade and in the wholesale clothing trade men and women only work fifty-four hours or less, though in the latter legal overtime brought up the average to fifty-six hours in 1891.[1] In 1872 one hour was taken off in Bradford woolcombing without legislation, and a fifty-nine hours' week was common in many places before 1874, while sixty hours were still legal; full work was often not done between noon and one o'clock on Saturday before the recent legislation. Hours in general in men's trades are fifty-four or less without legislation, though overtime is not uncommon. Employers and workers often admit that overtime, where allowed, is not economical, and that 56½ hours is as long as women can work efficiently. Employees are very anxious to get off in the evening; the rearrangement in 1874 intended to make work begin half an hour later has been generally used to stop work half an hour earlier.

Without the Acts it seems certain that less uniformity would have been obtained, and that in many cases excessive hours would now be worked; and it is not easy to instance any occupation where the hours would probably have been shorter.

Various opinions were held on the questions whether the Acts were a serious hindrance to employers in any respects, and whether they had any effect in making trade more regular, or in equalising employment through a district. In the specially seasonal branches of the textile industries the absence of elasticity is sometimes felt, and some manufacturers wish for regulated overtime, as allowed in the wholesale clothing trade. A silk manufacturer near Bradford stated that his weavers could only average fifty hours a week through the year, but that he had to refuse orders in the busy season. A Leeds worsted and wool manufacturer found that his whole work was hindered and orders lost by the impossibility of employing knotters and menders overtime. One Leeds clothing firm desired more legalised overtime to make up for lost time; another found the present allowance sufficient; small firms feel the restriction more than large; others admit the difficulty but do not recommend any change. In 1895 the Leeds Chambers of Commerce made the following representation to the Government: 'The time allowed by Section 53 of the Act of 1878 should remain as it is, subject to the inclusion of the woollen textile industry. . . . The time allowed by that Act (thirty days' overtime in the year) is not excessive, having regard to the particular stress of work and orders there is at special times of the year. Owing to the altered circumstances of trade and the altered conditions under which the woollen trade is now carried on, that trade should have the same advantages granted to it as are granted to the wholesale clothing trade.' I could not find, however, that there was in 1901 any strong or widespread feeling in favour of the extension of legalised overtime.[1]

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[1] *Factory Inspector's Report*, 1891.

Owing to the system of commission weaving, a firm can take more orders than can be executed in its own premises; and by this means a pressure of work can be distributed, if not directly among the factories, at any rate indirectly by the commission weavers taking work from the busiest firms. The exact nature of the pressure differs greatly from town to town, and factory to factory. There was no evidence that the effect of the Acts was to diminish the inequalities of the seasons. On the whole it seems that the manufacturers are not seriously inconvenienced by restricted hours, except in special branches for short periods. A few extra hours would allow some employers to accept orders they would otherwise refuse, and be more punctual in delivery; some orders may under present circumstances be placed in Germany that would otherwise go to the West Riding; but there is no evidence that the West Riding, as a whole, cannot cope with its work, and at the most the restriction of hours would be only a minor cause in displacing trade.

As regards wages, it must be admitted that it is impossible to determine whether the reduction of hours in 1874 had direct effect on wages or not. So many important changes and events took place about that time that the effect of the diminution of the working week by one-twentieth must be masked by other changes. General wage statistics are not sufficiently accurate to enable us to identify a particular change of 6*d.* per week. No one I spoke with recollects any specific change in weekly, hourly, or piece rates. Two combers state that there was no change in wages in 1874, but that there was a gradual fall after that date. Manufacturers near Bradford, at Batley, and in Leeds agree that the rates were unaltered; thus all on weekly wages obtained the same after as before the change in hours; but those on piece-rates (that is, all the weavers) earned less, except in so far as they could make up by increased hourly output; whether they made up the difference or not is a question on which various opinions are held, but there are no statistics to back them.

In the clothing trade, it is said, the price list hung up in accordance with the 'particulars' clause tends to make wages more uniform and to level them up.

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[1] For confirmation of this see *Factory Inspector's Report* for 1900 (Cd. 668), p. 275, *re* overtime allowed for War Office contracts.

The smaller workshops have recently come under more efficient inspection. One of the lady inspectors reports that under inspection they often become of a higher class, do better work, and attract better workers. The same improvement takes place in laundries.

In some cases girls take out-work in order to work longer hours than are allowed in the factory; and restriction of hours may thus tend to increase out-work; but in the main out-work is only taken from necessity by women who cannot leave their home all day.

Every enlargement of the field of inspection among the small workshops (the smallest of which are said still to escape inspection) leads at once to a shortening of hours and improvement of general conditions.

On all sides there was agreement that great improvements had taken place in sanitary conditions. The factory inspectors and medical officers work together, and a high standard is aimed at and is gradually being attained.

I now summarise the information I obtained on the lines laid down by the Committee:—

I. (1) The legislation of 1874 and the parts of the Acts since that date which are specially operative have decided the hours and conditions of women's work in the woollen and worsted industries; in the ready-made clothing trade the normal week is less than the legal hours, but overtime is closely limited by the Acts; in the boot trade the hours are less than the legal minimum. In respect of sanitation and safety the Acts tend to level up the worst conditions to the best.

(2) In many cases persons unrestricted by the Acts obtain employment at times, and of a nature decided by the Acts, chiefly in continuance of the women's work; also in a great part, but not the whole, of the woollen and worsted industries, men necessarily work the same hours as women.

II. (1) There has been no effect on wages directly traceable to the Acts.

(2) The cases in which women have not been employed because of restrictions are very few and unimportant.

(3) No important changes in division of labour or the use of machinery have been initiated by the Acts, but the regulation of the time of work has many intricate effects.

(4) and (5) There is no direct evidence as to the effect on women's industrial or social efficiency, but there is general agreement that longer hours would be harmful, and that the existing restrictions are beneficial.

In general, it may be said that the whole industry of the West Riding is moulded to suit the peculiar conditions of supply and subdivision of work caused by the prevalence of women's and children's labour, and the Factory Acts have had considerable influence in determining the nature of the supply of labour in detail. The Acts have had no perceptible and traceable effect either on the amount of trade, or on the main lines of the subdivision of work, or directly on the amount of earnings, all of which are decided by wider-reaching influences; but their effects on the comfort, health, and regularity of the lives of the workers have been great and beneficial.

III.—*Report on Birmingham.* *By* Miss B. L. Hutchins.

In the course of rather more than a three weeks' visit to Birmingham twenty-two factories have been visited, six workshops, and several factory women and girls in their own homes. Three of the manufacturers seen declined to show the works, but consented to answer a few questions. The majority of works seen were devoted to the manufacture of brass, jewellery, and other metal wares; the workshops visited were tailors' and button-makers'. Interviews were obtained with Mr. Knyvett (H.M. inspector of factories), with Mr. Parker (inspector of nuisances), and Mr. Keasey (inspector of workshops); also with four trade-union secretaries, two doctors (one a lady), and with one or two persons interested in the condition of working women. The questions put usually fell under the heads of employment, hours, and wages. The interviews obtained may perhaps be considered fairly representative and characteristic of the typical metal industries of Birmingham in which women are employed; but it is probable that so short and inadequate a study gives far too favourable an impression of industrial conditions generally. A stranger paying a visit of only a few weeks' duration is hospitably shown whatever is best, and I was warned more than once that I should not see the worst. It is obviously very difficult, if not impossible, in that space of time to become acquainted with the lower walks of industry, the small masters, and the sweated tailors and dressmakers. I was told that very black spots exist, in which no attention is paid to sanitary regulations and the hours worked are unduly and miserably long. By the kindness of the inspector of workshops and one of the health visitors I was able to pay a cursory visit to a few workshops.

Questions as to employment were intended to elicit information as to Query II. (2) of scheme. The evidence on the whole is, with one important exception, practically unanimous that the legal limitation of the hours of labour is no bar to the employment of women. Questions as to competition between men and women were invariably taken by the answerer to mean, not the encroachment of men on women's work, but of women on men's. The influence of women's competition in lowering the wages of men is felt to be a real and present danger to the standard of life of whole classes. But the idea that a man's legal freedom to work unlimited hours can cause a restriction of the woman's field of employment is entirely unfamiliar to the industrial world, and a direct question on this head usually elicits a flicker of amusement. Birmingham manufacturers do not as a rule worry about being restricted by law to work between 8 A.M. and 8 P.M., because custom, trade-union pressure, or their own ideas of profitable working usually restrict them between 8 A.M. and 6 or 7 P.M., and the influence of legislation in shortening hours (at any rate in metal industries on a large scale) is interesting chiefly from its historical significance. There can be no doubt that the hours of work were formerly much longer, and that the Factory Acts, after being bitterly opposed by the manufacturers, taught them a valuable practical lesson of the bad economy of excessive work. Mr. Baker has recorded a case of a Birmingham firm of button makers who in 1866[1] became so dissatisfied with the conditions and mode of life of their workpeople that they voluntarily applied the provisions of the Factory Act for textiles

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[1] *Report of Factory Inspector*, 1870, xv. p. 44.

(1844) to their own factory, and found its advantage. A similar case has been told me here by another manufacturer from his own experience. Others, although not old enough to remember so far back, have explained to me most carefully the bad economy of overtime. In former times, when customary hours were longer, it would seem that in cases where the men's work required the assistance of women in distinct but complementary operations, as in the tinning and enamelling trade, the Factory Act resulted, not in the substitution of men for women, but in the shortening of men's hours also.[1]

The tendency is evidently in the direction of a still further shortening of hours in some quarters. 'There may be a limit to which hours can be profitably reduced, but we haven't found it yet,' was one remark. Many employers prefer to stop work at 6 rather than give an interval for tea; a firm of hinge manufacturers have recently made this reduction, and considered that more regular work was obtained. Others, again, seem to prefer to take the interval and work a little longer, one giving the reason that 'the girls *would* have their tea'; while another, whom I heard of at second hand, thought 'the girls worked better after tea.' On the other hand the meal-times regulation is sometimes felt as a grievance, but not very acutely. The same hinge manufacturer considers the 'period of employment' a grievance in summer, and thinks it would be better for hands to work early and late rather than in the middle of the day. The managing foreman at a firm of printers finds it a distinct inconvenience not to be able to keep women to work overtime in turn, as he only requires about two women twice a week, and dismisses them other days well within legal limits. These, however, are comparatively trivial and inconsiderable objections. The 'important exception' alluded to above is a well-known manufacturer whose indictment of legal regulation of women's labour is all the more formidable in that he is himself an advocate of shortening hours on economic grounds, and women in his employ work only forty-eight hours a week as a rule. This gentleman disapproves of the fixed 'period of employment,' and charges the Act with hindering women from rising in their trade. Women *are* employed, he argues, but at a disadvantage: they are prevented, in his opinion, from holding responsible positions as managers, for which they are perfectly competent, by the fact that on an occasional emergency they cannot be at hand to deal with it. It will be seen that this attack is strictly relevant to the scheme of investigation, while on the other hand it cannot well be met by evidence from manual industry alone. His case is that the Factory Acts disqualify women for the higher and better remunerated posts, and thus restrict *la carrière ouverte aux talents*, and it is no answer to him to show that women are in great request for lacquering or machine tending. Part of this argument, however, tells both ways; for the development of industrial efficiency in women may itself be due to the regulations of the Acts. If the conditions of women's work have been humanised, and the strain of it diminished, industry itself may have been made more attractive, and drawn a larger number of recruits from good homes and healthy families than would otherwise have been the case.

As to Query II. (1) the general notion seems to be that women's wages *have* risen in Birmingham industries. The brassworkers' secretary attributes the rise to the operation of the Acts themselves. He thinks the effect also very important with regard to men's labour. I cannot say that anything I have heard or seen here gives me the impression that at the present time wages in factories are at all affected one way or other by the Acts While attributing the greatest importance to the early Factory Acts, which set limits to the exploitation of labour, and thus, by restricting hours, indirectly helped to raise the standard of life and wages and to promote labour-saving machinery, it is impossible to blink the fact that at the present day the legal regulation of hours is out of date as far as factories are concerned, and therefore does not much help or hinder industrial development. Things, however, are sometimes very nicely balanced, and it is very likely that if the nine hours' day had been enacted in 1874 and 1878, instead of being gradually introduced by custom, some of the laborious hand presses might have disappeared by this time. A similar effect would doubtless be produced by a rise of women's wages. It seems to be agreed that women's wages *have* risen; I can only say they seem to me very low. There is often an extra clever girl or two who earn particularly good wages, which are mentioned as showing things are fairly good for women. But one strongly suspects that these cases are exceptional: nine, ten, or eleven shillings is probably the average, and the nice pleasant-looking girls one often sees doing ill-paid work are said by those who know to be living at home, and only partially supported by their earnings.[1]

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[1] See *Factory and Workshop Commission*, 1876, Minutes of Evidence, Query 6505.

It should be mentioned here that some persons most intimately acquainted with the Birmingham women do not consider that a further reduction of hours would be morally desirable. I was told both by a clergyman at work in the poorest district and by the lady health visitors, 'The hours of work are no grievance here'—in one case, 'There ought to be a law to make them work *enough*!'—and it seems a pretty general conviction among observers of this class that the women are better at work than at play. I record this observation without comment.

It is found that the 'particulars' clause of 1900 is of great benefit in the pen trade. Payment is made at so much per 'lot,' and the lot is said to have contained an indefinite and varying number of pens, while the women did not know even the nominal number. Now a statement of the number of gross to each lot is hung up in the rooms, and the only trouble is in connection with the counting or weighing the work.[2]

In the development of safeguards on machinery the law is much more evidently and actually at work. I was several times shown appliances for reducing the risk to hands and fingers, carrying off dust, and so forth, and employers seem conscious that it is not only their duty but their interest to be forward in the matter. More than one (possibly with a mistaken impression that the inquirer might have some sort of official sanction) adopted an apologetic tone as to some of his processes, and explained that he hoped to improve them gradually, showing what had already been done. It is in these directions, the provisions for health and safety, that Mr. Knyvett considers the factory inspector exercises his most important function in modern times, and one is strongly inclined to agree with this view. The very fact that appliances and safeguards have to be used, thought out, and paid for puts a premium on the generous and thoughtful employer, and tends towards the crowding out of the unfit; and much the same can be observed in the sanitary administration of workshops. The Factory and Workshop Act and the Public Health Act become in the hands of the sanitary authority a really civilising force. Pressure is steadily put on to enforce a minimum of cleanliness and decency, and it is made inconvenient to fall short of it. There is distinct evidence that women have lost their employment in workshops from the requirement of the Acts. In about twenty workshops, Mr. Keasey thought, women had been dismissed, and boys taken on in their place, because the women were in so small a minority that it was not worth the masters' while to provide separate sanitary accommodation for them. Here we see that the most ordinary requirements of civilised life may inflict hardship, or what may be construed as hardship, in individual cases. Mr. Keasey, however, thought that the women probably found employment in other shops where their own sex was more largely represented, and it is not very likely that even an extremist would object to the working of the Act in similar cases. In the enforcement of sanitary regulations we see one of the most, if not *the* most, important agencies of such reform at work, and it is impossible to doubt that the women employed under these better conditions do become thereby more 'efficient,' both industrially and 'as members of society.' The effects of the legislation and its administration become more and more evident as the elder generation, to whom reform may be a stumbling-block and rock of offence, becomes superseded by the younger, which has time to grow up in better ways.

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[1] It would be a curious question for study whether the Factory Acts may not really have had some effect in lowering the money wages of women in so far as, by improving the health and decency of the factory, they cause larger numbers of respectable girls to be attracted to the work. In Birmingham there seems some tendency among girls to segregate themselves in the same factory into 'non-competing groups,' the distinctions between which are determined by the pleasantness or supposed gentility of work rather than by money wages. So long ago as 1857 Mr. Wright noticed that the warehouse girls were worse paid, and yet considered more respectable than the workshop hands (*Soc. Sci. Trans.*, 1857, p. 538).

[2] See Miss Squire's Report in the *Annual Report of the Chief Inspector of Factories and Workshops for the year* 1900 (Cd. 668), pp. 400-2.

IV.—*The Boot and Shoe Trades of Bristol and Kingswood.*
By Mr. G. H. Wood, *F.S.S.*

In writing the following report I am able to utilise a personal experience as a worker in the trade for some time, and have for some years closely watched its development. My personal experience was as a clerk in a boot factory.

When the industry was first brought under the Factory Acts in 1867 few workers were affected by them in this district, as the system then obtaining was almost entirely domestic. Nearly all the work was done at that time in small workshops at home for local retailers or for middlemen selling to local retailers. Hence the industry has grown up under the Acts, and has not been prevented by them from developing itself.

There are two distinct districts and two distinct trades in Bristol and Kingswood. In Bristol the light boots are made; in Kingswood the work is 'heavy-nailed' work. In only one or two cases do the same firms make the two classes of boots, and few of the workers are able to work at both. This division of the trades is essential and important. Machinery can be more easily applied to the light than to the heavy work, and for this reason the system of machine production has worked out from the Bristol light trade to the Kingswood heavy trade. Hence the small producer in the workshop has in Kingswood long outlived the producer under similar conditions in Bristol.

There are also two distinct seasons, and as the workers are not able to shift from one branch of the trade to the other there are always some of them idle. The heavy trade is usually slack from January till the end of June, very busy from July till October, and moderately busy during November and December. The light trade has two seasons, the first four months and August and September being busy, while the rest of the year is slack. In one or two places attempts are being made to cater for both trades, and if this is successful the trade may become a fairly regular one.

The wholesale trade started about thirty years ago with the introduction of the rivet system. Although this has affected the character of the work done by men and boys, it has not much altered that of the women and girls. There are still the two chief divisions of labour, machinists and fitters, with perhaps more of the former than the latter. For many years after the introduction of the rivet system men's work was given out to be done, and the indoor system grew up with the extension of machinery to various operations; but women were not affected by this, and their work would probably be done at home to the present time if the power sewing-machine had not been introduced. Before that invention the sewing was chiefly done at home; now it is chiefly done in the factory.

Manufacturers and workers agree in attributing most of the changes in the customs and regulations in this trade to these inventions. Machinery made the factory and the employment of capital necessary, and the Factory Acts have not hindered but furthered this development.

The power sewing-machine was introduced into Bristol about ten years ago, and came generally into use about five or six years ago. The work is much lighter for women now than formerly, and more work is done per head per annum.

In *Bristol* the work is usually day-work. When, some years ago, out-work was general, it was invariably piece-work; and, although this method of payment obtained for a time after the advent of the factory system, its replacement by day-work had commenced before the introduction of the power sewing-machine. In *Kingswood*, where more out-work is done, the out-workers are piece-workers, and the indoor hands usually day-workers. In some places a system of task-work is in vogue where the workers are paid a fixed wage, but have to do a certain amount of work. If this amount is not done in one week it has to be made up in the next.

Have the Acts introduced any change of custom in the case of the women themselves?

Yes. The trade being a seasonal trade, there has usually been a lot of overtime worked. The Acts have tended to put this down. On all sides there is evidence of a decreased use of overtime, and this has had the effect of making the industry more regular. Therefore *all* workers have been affected. In the case of women workers the 'nuisance' of having to register the overtime worked, and the limit of that overtime to a certain time at night and to thirty occasions in the year, has led employers to do all they can to keep it down. On the other hand the usual hours obtained by the action of the men's trade-union are fifty-four and fifty-one, and are thus below the limit of the Factory Acts. A factory cannot be profitably worked by men alone, and when the women and young persons are not at work the men generally have to leave off. This has not had the effect of keeping women out of the trade or of introducing more of them in proportion. It has simply had the effect of spreading the work over a longer period. It affects all employers alike, and therefore does not press unfairly on any one.

Years ago it was the custom to work day-work indoors and piece-work outdoors. Women were often allowed to take work home after the day was done, to finish and return on the morrow. Generally this was at their own request; sometimes it was required of them. Manufacturers found it did not pay. The women were not so fresh next day after working half the night, and in some cases were tempted to 'slack' work during the day, so as to have it to do at night. It also made them irregular in attendance, and it did not pay the employer to have his capital lying idle. The women bought their own machines for home work, and their employers bought the factory machines. The employers, therefore, wanted the work done as much as possible on their machines, and the custom was dying gradually. The Acts of 1891 and 1895 entirely killed it, and I could not now find a case of its being done illegally.

I cannot find that this change has affected any other workers than those immediately concerned.

The requirements of the Acts have also induced an extension of the factory system owing to the enforcement of the 'health' regulations. Formerly the industry was carried on in small dilapidated workshops, unsanitary, and affording no separate conveniences for the two sexes. Bit by bit these older places have been improved or done away with, chiefly because of the continual objections of the factory inspectors that they did not fulfil the requirements of the 'health clauses' of the Acts. Only the larger manufacturers could afford to make the required alterations, and manufacture on a large scale has thus been accelerated.

The extension of the principle of limited liability to the trade seems to account for some of the improvement in sanitary arrangements. When the trade was a non-machinery one, and where it is so now, as in parts of Kingswood, the sanitation only just reaches the minimum of the law; but where the large factories have been erected and run with plenty of capital (limited liability) and expensive machinery, the sanitation is very good. This also applies to the stay and clothing trades. Miss Collet, when visiting Bristol for the Labour Commission, commented in her report on the poorness of Bristol factories except two, the cocoa-works and the Bedminster tobacco-works. Since her arrival there has been a rapid extension of the factory system for women, and the methods in the boot, stay, and clothing trades have all been revolutionised by the introduction of the power sewing-machine and by the production on a large scale for export. Several new factories have been erected, either inside the city or in the adjoining neighbourhoods where the electric trams run, and these have the most modern sanitary conveniences, lofty rooms, improved methods of warming, and everything which is calculated to get more and better work done and to keep the workers from minor ailments, as headaches, colds, &c., which in factories cause much irregularity of working. Men cannot set up in business now on a small scale as they used to do, and it was the small employers with wretched out-houses who offended most against the sanitary and ventilation regulations.

Thus, while the Acts have tended towards the substitution of large manufacturers for small, the natural evolution of the industry has only been accelerated, and the change of custom cannot be wholly ascribed to the Acts ; in part, I am convinced it may be so.

Has factory legislation raised or lowered wages?

So far as my evidence goes wages have sometimes fallen *temporarily* and risen again, but there seems some doubt whether annual earnings have been altered *permanently* or not. The opportunities for working overtime being fewer seem to have diminished the earnings during the busiest weeks, without having any effect on the normal rate. Manufacturers and workers agree that there has been little change of wages for the ordinary week over a series of years, though there is evidence of a rise since 1883 ; but the earnings per annum seem not to have been affected thereby at all. The employers say earnings have been lessened through the reduction of opportunities for working overtime, yet they say also that the industry is more regular and the busy season is spread over a longer period. At this rate there seems to have been a clear gain to the workers. What has happened in the case of the men through the introduction of the machine system seems to have happened to the women through the same cause, and I am inclined to think that even the reduction of overtime is more due to this than to the Factory Acts. The men used, as hand workers, to be able to earn more during the busy season ; but though their earnings in a full week are now somewhat less than at that time, the annual earnings are greater. This remark would seem to apply to women, with the difference that for a 'full week' a 'week with overtime' must be substituted, the overtime being worked either at home or in the factory. None of the women workers I have interviewed consider that the Acts have affected wages at all. They have not lowered or raised them or prevented them from rising. They believe that with an efficient trade-union their wages would rise considerably, and that they have not risen lately because they have not been able to uniformly take advantage of good times.

All witnesses agree, and my own experience enables me to confirm, that there has been no alteration in the character of the machinery due to the Acts, none introduced from that cause, and no displacement of women. (But see note as to Kingswood, p. 304.)

The effects of the Acts on efficiency.

Here, in my opinion, is where the Acts have affected women. There is a consensus of opinion that women are better workers than formerly, and that indoor workers do more than outworkers in a given time. It is difficult to apportion the amount of increased efficiency due to the Factory Acts, but there are three main reasons why their efficiency has increased. These are :—

Improved machinery and more regular work ;
Better rooms to work in ;
Less amateurism and more work done as a serious occupation.

A comparison between the outdoor treadle-machinist and the indoor power-machinist cannot be legitimately made, but a comparison of the outdoor treadle without power with the indoor treadle-machinist shows the latter to be the better worker. The present day treadle-machinist working indoor is a better worker also than her predecessor. This shows increased efficiency, and is due to (*a*) better and more regular methods of working ; (*b*) better accommodation.

(*b*) is almost entirely due to factory legislation, while (*a*) is partly due to the same cause through the decrease of overtime.

I have referred to better accommodation of the workers and its causes. Its results are found in the constancy of attendance, there being now less minor sickness than formerly and a more cheerful attendance to work. Under the conditions prevailing in the old tumbledown workshops headaches and petty sicknesses were common, and were due to low ceilings, overcrowding, and bad ventilation and warming. The factory inspectors have been assiduous in pressing upon employers the necessity of giving the workers better accommodation, and this has had the desired effect. Instead of just fulfilling the health clauses the present factories—at least those wherein two thirds of the workers are engaged—exceed them. The rooms are higher, lighter, and better ventilated.

This has, of course, affected all alike, and the effects on the men are noticeable. Where the work is entirely hand-work much room, especially overhead, is not required. The advent of machinery, especially the larger machines, meant more space per worker and *more light.* Hence the rooms are larger and better. But in some parts of the factory where machinery is not employed the rooms are also larger and lighter, with the consequence that a man can do better and more work than ten or twenty years ago at nearly similar tasks.

This efficiency is due, then, to two sets of regulations : (*a*) overtime ; (*b*) 'health clauses.'

By forcing the employers to make their trade as regular as possible the overtime clauses have operated towards increased efficiency, and by forcing them to have better and lighter rooms the health clauses have operated towards the same end.

I have had no expression of opinion whether the Acts have affected women in their home life.

On the morals of the workers there has been a marked effect. 'Saint Monday' is now a thing of the past, and just as irregularity conduces to drunkenness and irregular living, and the rush of overtime at the end of the week, with nothing to do in the early parts, induced an irregular and careless mode of life, so the comparative steadiness of the present methods has tended to raise the standard of morality and sobriety. But a far greater cause has been the improved sanitary arrangements. Fifteen years ago I remember many closets in the Bristol factories which were absolutely unfit for use. Males and females were supposed to use the same ; the males used them, but in *many* cases the women would not. I have heard of cases where women suffered from internal disorders through having to wait until they got home, instead of using a closet in the factory. In some cases the women and girls used a bucket, emptied by one of themselves after leaving off at night, and being kept in the workroom all day. This is now done away with, and separate provision of a decent sort is made for both sexes.

The effects of the old loose system on the morals were bad. Much loose language was common, and coarse jokes were very frequent. The system was an inducement to immoral relations, and cases were known where illegitimate children resulted from them. A better class of girls is now employed, and that this has been possible is in part due to the removal of these evils.

SUMMARY.

I conclude, then, that factory legislation has altered some customs of the industry, and without really affecting earnings has increased the efficiency of the women workers. It has also raised the standard of morality for all.

Note on Kingswood.—These remarks apply to both districts; but in Kingswood the factory inspector notes that the Act of 1895 was a direct cause of the extension of the factory system. This Act prohibited overtime for young persons, and it was then the custom for a man to work in a workshop attached to his own house, with perhaps five or six boys. Denied the opportunity of earning a good wage through this overtime the lads left the trade, and the men in small business could not compete without their labour. The factory proprietors took advantage of this opportunity of boy labour, and an expansion set in immediately. The Acts have therefore induced the application of machinery and hastened the extension of the factory system. The effect of this is seen in that the Kingswood heavy trade is now nearly as much a factory industry as the Bristol light trade.

V.—*Leicester and Northampton.*

[Compiled from Mr. R. Halstead's Report.]

Mr. Halstead obtained information from employers in four hosiery firms in Leicester, Hinckley, and Loughborough, and from two trade-union officials and two women workers in that trade. In the shoe trade he interviewed managers of seven co-operative manufacturing societies in Leicester, Barwell, Glenfield, Desborough, Kettering, and Rushden, a private employer in Leicester, three officials of employers' associations at Northampton and Kettering, and six trade-union officials in Leicester, Northampton, Kettering, and Rushden. Information was also obtained from one employer in the box trade, one employer and one manager in the corset trade, one employer and one manager in the ready-made tailoring trade, one manager in the elastic-web trade, and two employers and one woman worker in the hat and cap trade.

I. (1) The general opinion expressed was that legislation regulating women's labour has had little to do with moulding the more important customs of the trades. Employers attributed the customs of their trade mainly to the nature of the machinery they employed and the resulting subdivision and organisation of labour. Several, however, thought it possible that legislation had increased the pace and brought about uniformity in factory reform. One manager thought it had in the first instance decided the customs of the boot trade as to hours of work and sanitation, but that since this initial stage the trade generally had been in advance of legislation. A few employers, who had been in the habit of employing out workers, said that the recent more stringent regulations as to out-work were having the effect of driving the work into their factories; but the change was mainly due to a growing desire to have all work under one supervision inside the factory. The trade-union officials attached more importance to trade-union action in fixing customs, although by one of them it was held that legislation had been one of the means of enforcing what had been won by trade-unionism.

(2) As to the effects of legislation regulating women's labour on other workers, practically no information was forthcoming; the new Saturday rule is an instance of the limitation of men's hours being secured by legal limitation of those of women and young persons.

II. (1) No effect of the legislation on women's wages had been observed. There was a general agreement that overtime was not economical.

(2) In the hosiery trade at all points of the inquiry there came out the fact that women were displacing men through the rise of new machinery. In the boot trade it was alleged that women were, to a slight extent, displacing men owing to falling wages, although the tendency was probably less marked because of the high wages in the hosiery trade for women's work.

(3) In none of these trades were the Factory and Workshop Acts credited with having initiated any important changes in the use of machinery or the division of labour.

(4) There was a general consensus of opinion that shorter hours and better sanitation enforced by legislation had been amongst the causes tending to increase the efficiency of women workers.

(5) Greater diversity of opinion existed as to the effect on their social life. While considering that with the rise of the factory system there had been a moral improvement, this was attributed by some to the factory system itself, not to factory legislation. Again some of the bad effects, consequent upon young women having more money and more leisure, and being therefore too soon set free from parental control, might also be attributable to the better organisation in the factory brought about by machinery. One employer considered that the easier conditions of female employment had a tendency to increase the employment of married women in factories.

On the whole employers complained very little of inconvenience caused by the Factory and Workshop Acts beyond the initial difficulty of adjusting arrangements to suit new regulations, and the labour incurred in filling up forms and making lists. In some cases, increased demands with regard to sanitation and guarding of machinery pressed rather heavily on employers, and, in one case, the recent change in the Saturday half-holiday was resented as being passed merely in the interest of the football fraternity (although nominally a restriction of the labour of women and young persons).

VI.—*Canning Town and Isle of Dogs.*

[Abstracted from Miss Hadley's Report.]

The difficulty of any investigation in these districts is very great; the employees are on the whole quite ignorant on the subject of the Acts or their administration, and are also afraid to give information. Some interviews were obtained with employees in bookbinding,[1] hat making,[1] tailoring, sweet factories, laundries, &c., and with other people well acquainted with the districts concerned. The evidence is not very definite, but the following statements seem to be correct. The hours in small workshops have been reduced in recent years. In one laundry the hours are now from 8 A.M. to 7 P.M., instead of till 9 P.M. as last year, and in

[1] In other districts in East London.

a sweet factory they have been reduced quite recently. Sanitation has recently been much improved. The special rules applying to white-lead works have excluded women from part of the work. In the bookbinding trade the Acts have not caused any displacement; if overtime is necessary the men take on the women's work when they leave at night. In tailoring there is no prospect of the dearer labour of men replacing that of women. The out-workers' list is expected to have a good effect, now it is attended to, those who take out the work endeavouring to keep their houses clean to satisfy the inspector. The 'particulars' clause is stated to have introduced no change in the tailoring, at any rate in the better class work, since accurate tickets were already supplied. It is held that the Acts regulating hours are operative, and together with the provisions regarding safety and sanitation tend to drive the small employer out of the tailoring and laundry trades, thus tending to increase work on a larger scale. Greater regularity in hours is enforced, and this tends to put the work in the hands of a better class of employees.

VII.—*Switzerland.*

Federal Legislation.

In Switzerland the separate cantonal legislation of the industrial cantons prepared the way for the general federal law of March 23, 1877, on which all subsequent legislation has been based. This law applies to all factories where a number of persons are employed within doors, away from their homes, and the majority of its provisions apply to adult workers of both sexes as well as to children and young persons. A wider application was given by the federal decree of June 3, 1891: this decree brought within the scope of the law establishments employing more than five persons and using motor power, or employing persons under eighteen, or satisfying certain other conditions.

The hours of labour may not exceed eleven, exclusive of at least one hour for meals; if the midday pause is less than 1½ hour, women who have a household to manage may leave work ½ hour sooner than men. Men and unmarried women over eighteen years of age may also be employed in necessary subsidiary work, such as cleaning, before or after the regular factory hours. On Saturdays and the days preceding public holidays the hours of labour must not exceed ten.

Sunday work is prohibited, except in cases of absolute necessity; and where furnaces are kept continuously going, eight days' holiday annually, to be arranged by the cantons, must be allowed in addition to Sundays.

Night work between 8 P.M. and 5 A.M. is forbidden from June to August inclusive; during the rest of the year 'night' work extends from 8 P.M. to 6 A.M. Exceptions are allowed in certain specified cases, but women may never be employed at night or on Sundays.

Women must be absent from employment in factories during eight weeks before and after childbirth, and on their return to work proof must be tendered of an absence since birth of the child of at least six weeks. Certain dangerous occupations or branches of industry from which women are to be excluded during pregnancy were specified by a federal decree of December 31, 1897, *e.g.*, processes in which white phosphorus is used, manufacture of lead or lead compounds, dry cleaning works, indiarubber works, &c.

Cantonal Legislation.

Cantonal legislation is largely concerned with the small industries which are so numerous in Switzerland, and which do not fall within the scope of the law of 1877. Seven cantons have passed special laws for the protection of workpeople: Basle in 1888, Glaris in 1892, St. Gall in 1893, Zurich in 1894, Lucerne in 1895, Soleure and Neuchâtel in 1896. Glaris is the only canton where the law includes adult males; the others are concerned only with women and young persons. The cantonal laws of Glaris, St. Gall, Lucerne, Soleure, and Neuchâtel contain special regulations with regard to women employed in shops; women in offices come under the protection of the law in Neuchâtel only. Special laws for the protection of women employed in hotels and cafés have been passed in Zurich, Basle, Glaris, St. Gall, Lucerne, Soleure, and Neuchâtel. All except Glaris prohibit the employment of girls under eighteen years of age as waitresses unless they belong to the family of the landlord. Women employed in hotels and cafés on Sunday must have a free afternoon in the week—once a fortnight in Zurich, and once a week in Basle and Lucerne.

The laws of Zurich, Soleure, and Neuchâtel extend their protection to single workers if occupied in a trade (*métier*) and in receipt of wages; St. Gall and Basle only protect single workers if under eighteen years of age; if above that age the law applies only where two or three persons are employed. Persons employed directly or indirectly by a large manufacturer, even when working in their own homes and using their own tools, are regarded by the law as wage-earners. Neuchâtel is the only canton which stipulates that the worker must be employed outside his own home to come within the scope of the law.

Cantonal legislation has followed the main outlines of the federal law of 1877, diminishing its rigour in some cases, in others supplementing its defects. The eleven hours' day has been accepted by most cantons. Zurich is ahead of the law in fixing the working day for women at ten hours, with 1½ hour's rest, and at nine hours on Saturdays and the days preceding holidays. Overtime of two hours a day, with a maximum limit per annum, is allowed by most cantons. The limit in Zurich, where least overtime is allowed, is seventy-five hours in the year. No one can be compelled to work overtime, and such work must be paid—except in Glaris—at a higher rate; in Zurich, Lucerne, and Soleure at 1¼ time the daily wage. In the German cantons, except Basle and Glaris, girls under eighteen years of age may not work overtime at all. No work may be given out to be done at home after working hours. Night work, except in Lucerne, is only permitted to women over eighteen years of age, and for certain definite reasons Basle and Glaris are the only cantons which have adopted the eight weeks' rest for lying-in women prescribed by the federal law. St. Gall and Lucerne require only six weeks, Zurich and Soleure four weeks. The appointment of cantonal inspectors is considered desirable. The only canton where such an appointment has been made up to the present is Zurich.

Insurance against accidents is provided for to a small extent in the cantons of Appenzell and St. Gall, where all workmen who are not citizens of the canton are required to join some benefit society.[1]

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[1] *Hygiène et Sécurité des Travailleurs dans les Ateliers Industriels*, pp. 91-93; *Congrès International de Législation du Travail*, pp. 393-398.

VIII.—*Holland.*

The law of May 5, 1889, applies to all industrial undertakings except agriculture, forestry, stock rearing, peat cutting, and fishing. It prohibits the employment of children under twelve, and places young persons under sixteen years of age and women of all ages under legal protection. Protected persons may be excluded from dangerous or unhealthy trades by royal decree. These industries are specified by the decree of January 31, 1897.

Protected persons may not work more than eleven hours a day, with at least one hour for rest between eleven and three o'clock, which hour may not be spent in a work-room.

Night work, *i.e.*, from 7 P.M. to 5 A.M., is prohibited, as also is work on Sundays and church festivals. This general prohibition of Sunday work was withdrawn on December 31, 1896, in favour of women over sixteen years of age employed in butter and cheese making, provided that certain conditions specified by an administrative order were observed.

Employers are bound to demand a labour passport from the mayor for each protected person in their service. These passports must give the dates of entering upon and of quitting an engagement; the hours of starting and of finishing work and the day elected as the weekly holiday must also be posted up in the factory.

Women may not be employed for the four weeks subsequent to their confinement.

Certain exceptions as to overtime were anticipated as necessary by the law of 1889, and they have since been dealt with by the decrees of December 9, 1889; October 30, 1890; October 17, 1891; and June 10, 1892. Overtime from 7 to 10 P.M. is allowed in certain industries (fruit preserving works, laundries, &c.) when necessary.

Women and young persons under sixteen are prohibited from working underground; but as only two mines employing some 300 persons are worked in Holland the benefit of this prohibition is theoretical rather than practical.

The execution of the law of 1889 was entrusted in the first place to three inspectors whose duties were defined by a decree of February 21, 1890. They are appointed by the Queen and placed under the direction of the Minister of Justice; their functions are to examine the labour passports of individuals, the factory registers, and to report all infractions of the law. The limitation of their number to three was removed by the law of July 20, 1895, and they were charged by the same law to substitute a half-yearly for a yearly report of their operations.[1]

The first legislative provision made in Holland for the health and safety of factory workers dates from July 20, 1895. This law prescribes the cubic space to be allotted to each worker, the ventilation, lighting, precautions against fire, and sanitary accommodation. Factories are to be kept clean and free from noxious gases or dust, and to have a comfortable temperature. Precautions are to be taken against accidents arising from machinery, explosives, boiling liquids, or molten metals.

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[1] *Hygiène et Sécurité des Travailleurs*, pp. 58–62 and 365–76; *Congrès International de Législation du Travail*, pp. 451–55; *Annuaire de la Législation du Travail*, 1897, pp. 268–79.

The special dangers arising from steam engines are safeguarded by the law of April 18, 1896. These laws are enforced by inspectors whose powers are similar to those of the inspectors appointed under the labour law of 1889.

Women and young persons were prohibited from working in any dangerous processes connected with the manufacture of matches containing white phosphorus by a decree of June 24, 1898, but the entire manufacture of such matches has since been forbidden (May 28, 1901), and their import, export, and sale forbidden, except in very small quantities. Transit through Holland is permitted.[1]

IX.—*The Grand Duchy of Luxembourg.*

The establishment of factories and workshops in Luxembourg is subject to the fulfilment of certain conditions as to safety and hygiene, which are deemed necessary in the interests of the public as well as of the persons employed in them.

The law of December 6, 1876, regulates the employment of women and children. The age for beginning work is fixed at twelve. Young persons may not work at night or underground. No girls or women may be employed underground.

This law was further amplified and defined by the decrees of August 23, 1877, and May 30, 1888, on the hours of labour. Children under fourteen years may work eight hours a day if provided with a medical certificate stating that they are fit; if not their maximum day is limited to six hours. Young persons under sixteen may not work more than ten hours, or eleven if they possess a medical certificate. The decree of 1877 also regulates the provisions for the health and safety of factories in which young persons are employed.

The employment of youths from sixteen to eighteen years of age in mines and quarries is subject to a law of April 30, 1890, and to a decree of January 7, 1891.[2]

X.—*Hungary.*

Hungarian law does not interfere with the labour of adults, whether men or women; the only restriction upon the labour of women over sixteen years of age is that which prohibits their employment within four weeks after confinement.

No special law exists for Hungarian mines: the conditions of labour are regulated by the Austrian law of 1854. A Bill on mining industries has been introduced since that time, but it has not passed. It must not, however, be assumed that in the absence of special legislation the conditions of labour in the mines of Hungary are less favourable than elsewhere. Women and children under fourteen years of age are hardly ever employed underground; the force of custom is as effectual as legal prohibition.

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[1] *Annuaire de la Législation du Travail*, 1898, p. 336; *Revue du Travail* (*Office du Travail de Belgique*), July 1901, p. 816.

[2] *Hygiène et Sécurité des Travailleurs*, pp. 63 and 377–83.

XI.—*Finland.*

By the law of April 15, 1889, women and children may not be employed underground, nor to clean or oil machinery in motion (Section 12).

XII.—*Russia.*

Modern industrial legislation in Russia dates from the year 1882. By the law of June 3, 1845, young persons under seventeen and women were not to be employed at night in cotton mills. Their employment was permitted in factories working with a double shift, provided that the head of the family was working with them. These regulations were extended in 1890 to all textile factories.

In 1886 (June 3) a law was passed on the hiring of workmen and the institution of factory inspection, which, from the extent of its application, may be considered as the principal labour law.

The inspectors of factories receive and examine disagreements between employers and employed and complaints; they visit places where strikes have occurred and notify to the chief inspectors the measures they have taken to bring about peace; they fix reception days once a week for the hearing of verbal explanations, and see that a notice of such days is hung up in all factories. They must obtain from employers notice of all enlargement or reduction of factories, of changes in the managing staff, of all cases of disturbance, of all accidents; they must obtain statistics of hours, overtime, employment of women, young persons, and children, and information on industrial statistics.

XIII.—*Sweden.*

By a decree of June 22, 1883, women were not to be employed within four weeks after confinement unless provided with a medical certificate stating that it would not be injurious to them to resume work. Women and young persons might not be employed to clean or oil machinery in motion. The Committees of Public Health might forbid their employment in industries of a particularly dangerous or exhausting nature. Employers must keep a register stating the age, degree of education, and the state of health of the protected persons in their service.

XIV.—*Norway.*

The law of June 27, 1892, on the inspection of factories, embodies all previous legal enactments for the protection of factory workers. This law embraces industrial undertakings, mining and metal works of all kinds. Doubtful cases are referred to the inspectors.

Women may not be employed (1) underground; (2) in cleaning or oiling machinery in motion; (3) for six weeks after confinement, unless provided with a medical certificate stating that they may return to work after four weeks without injury to their health; (4) in dangerous, unhealthy, or exhausting trades during pregnancy.

XV.—*Denmark.*

Factory legislation in Denmark originated with the law of 1852 on unhealthy industries. The same trades were further regulated by the law of 1858, but no protection was afforded to labour generally until the passing of the Factory Act of 1873 and the Act for the Prevention of Accidents of 1889. These laws, which have remained in force up to nearly the present time, are now superseded by a law published on July 1, 1901, which came into force on January 1, 1902.

The law existing in 1901 applied to all factories and workshops where steam or other power is used. It placed no restriction upon the labour of adults of either sex, but afforded a certain protection to young persons under eighteen years of age.

The chief features of the new law are :—

(1) The clause which prohibits the employment of women during the four weeks after confinement, except upon the production of a medical certificate showing that the mother's employment will not injure either herself or her child.

(2) The creation of an industrial council composed of a president appointed by the King and eight other members, of whom three at least must be employers and three at least employees, appointed by the Minister of the Interior. It acts as an advisory body to the Factory Department, and may investigate, on its own initiative, any question arising under the law.

(3) The organisation of the staff of inspectors as a factory department, at the head of which will be a director appointed by the King, with two secretaries, experts in economics and technology. The number of inspectors will be fixed by the legislature in the 'Budget Law,' but the Minister of the Interior may in the meantime appoint up to twenty inspectors. The number permitted by the old law was only two, with twelve sub-inspectors appointed by the Act of 1889.

(4) The provisions of the law of 1889 on the prevention of accidents are incorporated in the new law, which requires, in addition, that a minimum space of 282 cubic feet be allotted to each worker, and that efficient ventilation be secured, if necessary, by artificial means. Workrooms must be properly warmed, and employers are bound to provide rooms in or near the factory where their workpeople can take their meals. Provision for warming food must also be made wherever this is possible.[1]

The law on the prevention of accidents arising from the use of machinery, April 1889, forbade the employment of women to clean or oil machinery in motion. There are no other direct restrictions placed upon the employment of women by Danish law.

The number of women employed in industry in Denmark is, according to the census returns of 1897, 36,760, exclusive of employers, forewomen, &c. Of these some 13,000, or not quite *one-third*, come within the scope of the Factory Acts. The new Factory Act mentioned above will undoubtedly occasion a great extension of inspection, but it is of too recent date to give available results.

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[1] *Hygiène et Sécurité des Travailleurs*, pp 139–148 (*Labour Gazette*, August 1901).

The indirect results of the recent extension of factory inspection are of considerable importance as regards their influence, both on the hours of labour and on the general condition of factories. The following figures show how considerable has been the increase in the number of factories under inspection since the passing of the Act of 1873 on the labour of children and young persons, and the Protection of Machinery Act of 1889. In 1874, the first year that the former Act was in force, the number of factories under inspection was 673, employing altogether 21,402 persons, of whom 2,632 were children, 2,522 were young persons, and 16,248 were adults ; in 1900 the number of factories had risen to 3,652, employing altogether 78,206 persons, of whom 3,464 were children between ten and fourteen years of age, 8,295 young persons, and 66,447 adults, of whom 13,192 were women. The statistics compiled by the factory inspectors also show that during the years 1874–1900 there has been a tendency for the proportion of children to adults to decrease, while the proportion of young persons has recently increased. (The actual numbers are higher in both cases.)

—	Establishments			Children			Young Persons			Adults		
	1874	1890	1900	1874	1890	1900	1874	1890	1900	1874	1890	1900
Number . .	673	1,949	3,652	2,632	2,539	3,464	2,522	3,345	8,295	16,248	36,542	66,447
Percentage . .	—	—	—	12·3	6·0	4·4	11·8	7·8	10·6	75·9	86·2	85·0

The new law of April 1901, which raises the age for beginning work to twelve years, will probably cause a still further displacement of child labour.

Of the 66,447 adult persons under inspection some 13,000 are women: they are employed in small numbers in the same industries in which men are engaged, with the exception of gas-works and flour mills with mechanical power. The only industries in which they are employed to the number of 1,000 and upwards are the cotton, linen, and woollen trades, and the manufacture of tobacco and cigars. This fact has an influence on the hours worked by women, for though the hours of labour are only legally restricted for children and young persons, the result of inspection has been a notable decrease in the number of establishments working very long hours. These are now found only in the smaller workshops where one or two persons are employed, very rarely in the larger factories. The proportion of textile factories doing more than 10½ hours' effective work is only about 7 per cent., whereas as many as 47 per cent. work only ten hours. The following table shows the decrease in the hours of labour generally which has taken place since the institution of factory inspection :—

Percentage of Factories working not more than 10½ *hours a day.*

1874 . . .	41·7 per cent.	1890 . . .	73·8 per cent.
1880 . . .	59·4 „	1895 . . .	80·9 „
1885 . . .	66·6 „	1900 . . .	90·8 „

The debates on the new Factory Act raised the question of the extent to which women were employed at night, and returns from all the inspectoral districts showed that in all the industries under inspection only 127 women, or about 1 per cent., were regularly employed at night. These were distributed as follows :—

Cement works	2	
Glass do.	14	(working alternately from 4 A.M. to 1 P.M., and from 2 to 10 P.M.)
Paper do.	14	night and day alternately.
Printing do. . . .	40	some hours every night.
Sugar do. . . .	25	alternately day and night for two or three months in winter.
Chocolate and sweet do. .	11	from 8 to 10 P.M. during two months in winter.
Fish-net do. . . .	21	alternately 6 A.M. to 3 P.M., and 3 P.M. to 12 midnight.

Where the inspectors find that accidents, which are generally of a slight nature, have been caused by the employment of women to clean machinery in motion, they cause extracts from the law with regard to this particular to be hung up in the work-rooms where women are employed to tend machinery.[1]

The above information is derived from the Report of the Factory Inspectors for 1900–1901. Tabular statements of the number of establishments employing children, young persons, and mechanical power are contained in the official publication entitled 'Statistiske Oplysninger om København og Frederiksberg.' These returns, however, are only brought up to 1895, and the locality is circumscribed, whereas the Reports of the Factory Inspectors cover the whole country. It has therefore been thought unnecessary to extract the figures in detail, but the following table shows the same tendency to a decrease in the employment of children and young persons, as is noted by the inspectors:—

Percentage of Children and Young Persons in Factories under Inspection in Copenhagen and Frederiksberg.

—	Total No.	Children	Young Persons	Children and Young Persons
1891	17,604	4·6	9·1	13·7
1892	18,148	4·4	9·1	13·5
1893	19,187	4·3	8·7	13·0
1894	19,082	4·2	9·0	13·0
1895	19,787	4·1	8·5	12·6

Wages.—The official returns with regard to wages do not distinguish between the earnings of women employed in factory and non-factory industries; the annual earnings are 500 kr. as compared with 440 kr. in 1892. This rise had almost always been accompanied by a decrease in the hours of labour, and it was found that Sunday rest, first enforced by the law of April 1, 1891, was generally observed.

Mr. Marcus Rubin and Mr. Cordt Trap, who edited the statistics for the two periods, in their suggestions as to the causes of this rise of wages and decrease of hours, do not directly mention legislation, though Mr. Rubin refers to the increase of factory industry. They are rather inclined to lay stress on the general rise in the standard of life, and above all on trade organisation.[2]

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[1] *Forskellige Meddelelser. Beretning til Justitsministeriet og Indenrigsministeriet om Fabriktilsynets Virksomhed i Finansaaret* 1900–1901.

[2] *Danmarks Haandvaerk og Industri*, femte Raekke. Litra A. Nr. 1, 1899. *Arbejdslonnen i København i Aaret* 1892. Marcus Rubin. *Arbejdslonnen i København i Aaret* 1898. Cordt Trap. The Committee are indebted to Mr. Steffensen for copies of these works and other valuable information.

The Resistance of Road Vehicles to Traction.—Report of the Committee, consisting of Sir ALEXANDER BINNIE (*Chairman*), Professor H. S. HELE-SHAW (*Secretary*), Mr. T. AITKEN, Mr. T. C. AVELING (*Treasurer*), Professor T. HUDSON BEARE, Mr. W. WORBY BEAUMONT, Mr. J. BROWN, Colonel R. E. CROMPTON, Sir D. SALOMONS, Mr. A. R. SENNETT, Sir J. I. THORNYCROFT, *and* Mr. W. H. WHEELER. *Associated with them were* Mr. A. MALLOCK *and* Mr. E. SHRAPNELL SMITH. (*Drawn up, at the request of the Committee, by the Secretary, assisted by* Mr. J. F. GILL, *B.Sc.*)

PLATES III.-VII.

CONTENTS.

PAGE
I PREFACE 314
II. *The Works of Corréze and Manès* (1832) 314
III. *The Work of Coriolis* (1835) 315
IV. *Experiments and Conclusions of General Morin* (1837-42). 316
V. *The Researches of M. Dupuit* 323
VI. *Theoretical Investigation by Edmund Leahy, C.E.* (1847). 326
VII. *The Work of M. Charié-Marsaines* 329
VIII. *Experiments by A. Michelin* (1896) 330
IX. *Extract from the Report of Professor W. C. Unwin, F.R.S., on the Trials of Self-moving Vehicles at Birmingham made before the Royal Agricultural Society* (1897) 336
X. *Experiments by Professor H. S. Hele-Shaw, F.R.S.* (1897) 337
XI. *Investigations of Professor Ira O. Baker* (1902) 338
XII. *Summary of the Opinions of Various Writers on the Relation between Tractive Effort and the Various Independent Elements of Road Resistance* 343
XIII. *Description and Drawings of the New Dynamometer made for the British Association Committee to carry on the Researches* 345
XIV. *Nature and Scope of the Experiments by the Committee* 346
XV. *The Work of the Committee presented at the Meeting* 347

I. *Preface.*

THE first ten sections of this Report give a summary of the work done on road resistance from the earliest time for which records are available. It is quite possible that the work of some investigators may have been overlooked, but at the same time the chief results which have hitherto been made known are presented, for the first time, in a concise form. The work of most of the French observers has been drawn to a great extent from A. Debauve's 'Manuel de l'ingénieur des ponts et chaussées.'

It has not been possible to carry out during the present year in a sufficiently complete manner the experiments with the British Association apparatus in order to be able to compare the results obtained with the formulæ and laws which the summary gives, but it is hoped that by another year the work will have been sufficiently advanced to enable this to be done.

II. *Corréze and Manès* (1832).

MM. Corréze and Manès treated the subject from both theoretical and practical standpoints, and the conclusions they arrived at fully confirmed a series of experiments made by a commission of engineers in 1816, The following are their conclusions :—

That the resistance to rolling is composed of two elements: (i.) Friction of the wheel upon the road ; (ii.) axle friction.

(i.) That wheels of vehicles destroy the road in proportion to their load, width of tyres, and speed. If the tyres be narrow the friction may be simply treated as a rolling friction, but if the tyre be wide then a pivoting action is introduced.

The effect which a wheel produces upon the road depends upon the load upon the wheel, the resistance of the material of which the road is made, and on the nature of the surface. If the load be great and the tyres narrow, the wheel will form a rut in the road, but if the tyre be wide, the load becomes distributed and does not damage the roadway. A wheel travelling along a road badly kept or badly constructed meets with obstacles against which it strikes and surmounts with difficulty, and from which it falls to the ground again with a force proportional to its weight and the height of the obstacle. This action being continually carried on is very destructive to the roads.

In cases where roads are uneven, springs should carry the load, as they convert the series of shocks into a simple increase of pressure and preserve the horizontal component of the force, which otherwise would be lost.

The destructive effect of a wheel upon the road increases with the load, the speed remaining constant, but the rate of increase of damage to the road is far greater than the increase of the load.

The influence of speed is such that, with equal loads, on a well-kept road, the destructive effect of the wheel decreases with an increase of speed, but on a badly kept road the reverse takes place.

MM. Corréze and Manès proved, by direct experiment, that the ratio between the tractive effort and the load increases with the speed.

Carriages with four wheels in unequal pairs require less tractive effort than those with two wheels or two equal pairs of wheels.

(ii.) *Axle friction.*—By the contact of a spindle with its bearings a sliding friction is produced.

Suppose the coefficient of friction $= \frac{1}{10}$, and load $= P$,
Then total resistance due to axle friction $= \frac{1}{10} P$;
If ratio of radius of wheel to that of axle $= \frac{1}{20}$,

$$\text{Then } \frac{\text{resistance at axle of wheel}}{\text{resistance at circumference}} = \frac{1}{20}.$$

Therefore resistance at circumference $= \frac{1}{200}$ P.
But on a good road resistance to traction $= \frac{1}{25}$ P.
So the axle friction only $= \frac{1}{8}$ that of total resistance.

Edgeworth experimented and found, in 1808, that on a rough road a vehicle with springs had only one-third the resistance of one without, at 8·8 kilometres per hour.

III. *The Work of Coriolis* (1835).

Coriolis, a civil engineer, applied the theorem of work to the traction of vehicles and investigated the work of resistance. He proceeded as follows :—

Let F equal the tractive effort and s the distance run. Then the integral of the quantity F ds will equal the total work due to the reaction of the ground.

The work of resistance consists of :—

(i.) That absorbed by the play of the springs, usually negligible.
(ii.) That due to the action of the wheels upon the road.
(iii.) Axle friction.
(iv.) That absorbed by hills.
(v.) That due to the variation of the momentum, which may be neglected during a day's run, as the vehicle passes in a short time from a state of rest to its normal velocity.

Coriolis states that the tractive effort required is practically proportional to the work due to the action of the wheels upon the road and axle friction, the other quantities being negligible.

That axle friction is a sliding friction constant in value and independent of the extent of surface in contact, and can be reduced by altering the arc of contact, which is limited by practical considerations.

That the reaction of the road upon the wheel would be *nil* if the ground were infinitely soft, and equal to the load if incompressible. Neither case appears in practice, but the reaction is variable and increases with the compression.

If $p =$ reaction of the ground, $h =$ compression of the road, then work of resistance $= \int p\,dh = \int \frac{p\,dh}{dp} \cdot dp$.

The more rigid the ground the more will p increase with h ; $\therefore \frac{dh}{dp}$ will diminish with p, and the work will be less for a given value of p.

That the reaction depends not only on the nature of the road, but also on the diameter of the wheels and width of the tyres.

That on a homogeneous surface the resistance due to reaction

$$= \frac{a^3\sqrt{p^4}}{\sqrt{L^3}\sqrt{R^2}}$$ [1]

$a =$ coefficient that varies inversely as the hardness of the road ; $p =$ total load ; $L =$ width of tyre ; $R =$ radius of the wheel.

Coriolis drew the following conclusions :—

That to reduce the work due to resistance the road ought to have as great a rigidity as possible, and that the springs should be as flexible as possible.

IV. *Experiments and Conclusions of General Morin* (1837–42).

These experiments were made by General Morin, 1837–42, by order of the Ministers of War and Public Works, being carried out with the greatest care and under the most varied conditions. The results have been collected together into a large treatise, from which the following is taken :—

A Résumé of General Morin's Work on Rolling Friction.

(*a*) There is the simple turning of one curve upon another when the two curved surfaces are always in contact, and when the arcs passed through in a given time are of equal length.

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[1] This formula is midway between General Morin's and Dupuit's.

(*b*) Simple rotation of a cylinder upon an horizontal surface, when the surface formed on the plane is an envelopment of the cylinder.

A cylindrical body alone can roll upon a plane in a straight line. If the body be not cylindrical, the rolling motion is accompanied by a sliding one, or, what amounts to the same thing, a pivoting motion.

This action is particularly noticed when a wheel with a cylindrical tyre leaves one straight line direction for another, and such a wheel, when rounding a curve, is subjected to simple rotation and also a pivoting action about its vertical axis, and consequently tends to twist the wheel from its true position to take up a position relative to the curve.

Morin experimented in the following manner: Upon two parallel beams, with horizontal faces, were placed two loaded cylinders. In order to give motion to these cylinders additional weights were added, acting tangentially to the cylinders and parallel to the beams.

For different cylinders and surfaces the force required to impart motion was found by experiment.

The force thus found, which imparted a uniform rolling movement to the cylinders, must be that which just overcomes the resistance to rolling, for if the force were too great, the motion would become uniformly accelerated, and if the force were too little, the cylinders would come to rest.

Consequently, from the above it may be inferred that the moment of the additional weights about the axis of rotation is equal to the moment of the frictional resistance about the same axis.

Calling R the resistance due to friction, which is supposed to act tangentially to the wheel, of which r is the radius, p the pressure transmitted by the wheel to its supports, and A a constant; then we have

$$R = A\frac{p}{r}$$

which sums up the law for rolling friction.

From the experiments, which were made by Morin to ascertain the truth of Coulomb's Law, he drew the following conclusions:—

(i.) On fibrous materials, such as wood; on spongy textures, as leather; on granular bodies, as plaster: 'That the resistance to rolling varies inversely as the diameter of the wheel, measuring this force (R) at the circumference of the wheel.'

(ii.) On compressible surfaces: 'That the resistance to rolling increases as the width of the tyre diminishes.'

(iii.) On an elastic substance, such as indiarubber: 'That the depth of the depression is practically proportional to the pressure, provided that the elasticity remain constant; the depth of the depressions increases as the width of the tyre diminishes. The elastic reaction, or the force with which the substance tends to return to its original form (after the pressure has been removed) is not always very rapid even in the case of indiarubber, so it is much less so on a stone road; in consequence, it does not restore to the wheel the whole force expended on it. Even on railways, where the rails return very quickly to their normal shape, the speed of the train is too great for the vehicles to recover the work that has been transmitted to the rails.'

(iv.) On a homogeneous body, such as wood: 'That the pressure alters the elasticity, and that the resistance to rolling increases more rapidly as the pressure increases; consequently wood pavements are not suitable for heavy traffic.'

The law for the ratio of rolling friction to the pressure, enunciated by Coulomb and others, is not a general or mathematical law, but only approximately true for certain cases in which it is found useful to apply it.

Coulomb's Law.

$$R = A\frac{p}{r}$$

Values for A, the constant, are as follows:—

1. For oak wheels running on poplar boards, the grain of the oak being perpendicular and that of the poplar parallel to the line of motion	$A = 0{\cdot}000876$
2. For oak wheels on strips of leather	$A = 0{\cdot}001895$
3. For oak wheels on plaster	$A = 0{\cdot}000821$

Experiments on the Haulage of Vehicles.

For the following experiments, General Morin made use of three kinds of apparatus:—

I. A shaft, to which a number of equal pulleys were attached, so that the width of surface in contact could be varied; a number of metal discs were attached to the axle to act as a load.

The force required to produce uniform rotation was found by trial on well-beaten clay, fine sand, slabs of marble, boards, &c. In each case the resistance (R) was calculated, being equal to the motive weight multiplied by the inverse ratio of the diameter of the axle to the diameter of the pulleys. Thus it was found that the resistance varies with the load and other circumstances met with in the experiments.

II. A shaft carrying a number of discs to vary the weight, and having two wheels formed by a number of pulleys. In this manner the diameter of the wheel and the width of the tyre could be varied at will.

The axle was attached to a metal frame, to which one or more horses were harnessed. A dynamometer recorded the tractive effort by means of a pencil in contact with a roll of paper which was unrolled, the movement of the paper being proportional to that of the wheel, and the deflection of the spring to that of the tractive effort. The area of the figure enclosed measured the work.

III. A dynamometer was interposed between the shaft and the fore-carriage. The tractive force was quite easily transmitted by this method. Most of Morin's experiments were performed in this manner.

The causes that have an effect on the tractive effort and also tend to destroy the roads are:—

(i.) The weight or pressure upon the ground.
(ii.) The diameter of the wheels.
(iii.) The width of the tyres.
(iv.) The velocity of the vehicle.
(v.) The angle of inclination of the pull.
(vi.) The efficiency of the springs.

From each experiment Morin obtained a value for F, the tractive effort, or the pull exerted by the horse. This value corresponds to values determined from :—

The inclination of the ground	(i)
The inclination of the pull	(a)
The weight of the shaft and its additional load	(P)
The weight of the frame and pole . . .	(p)
The total rise of the ground during the run .	(h)
The distance run	(L)
The coefficient	(f)

Now $\sin(i) = \frac{h}{L}$, and the total pressure transmitted to the ground $= (P+p)$. Applying the theorem of work to the movement of the vehicle :—The force F acts through a distance L, and its direction makes with the surface of the ground an angle (a).

Therefore the work done in moving the distance L is equal to $FL\cos a$.

Work due to resistance is composed of :—

(i.) That due to the weight of the vehicle, &c., and which is equal to the weight multiplied by the total rise.

$$\text{Work due to weight} = (P+p)h.$$

(ii.) That due to the reaction of the ground upon the wheel :—Calling R that reaction or resistance to rolling, which acts tangentially to a wheel whose radius is r, and if the tyre develops itself exactly upon the road, the point of application of the force travels a distance L, then

$$\text{Work due to the reaction of ground on wheel (R)} = RL.$$

(iii.) That due to the friction of the axle in its bearings :—The spindle is acted upon by two forces, *i.e.* the pull F, which makes an angle of $(a+i)$ with the horizon, and the weight or vertical force (p). The resultant of these two forces is normal to the circumference of the axle, and is represented by the third side of a triangle, of which F and P are the other two, making between them an angle of $\left(\frac{\pi}{2}+a+i\right)$

$$\therefore \text{Resultant} = \sqrt{F^2+P^2-2\,Fp\sin(a+i)}$$

and if we multiply this expression by the coefficient of friction (f) we obtain the tangential rolling force applied to the spindle. The distance travelled by its point of application is equal to the distance (L) run by the wheel multiplied by the ratio of the radius of the spindle (ρ) to radius of the wheel (r).

Then the work due to the friction of the axle in its bearings

$$= L\frac{f\rho}{r}\sqrt{F^2+p^2-2\,Fp\sin(a+i)}$$

The velocity of the vehicle was kept uniform throughout the experiments, and the variation of the momentum of the system was zero.

The equation of work becomes—

$$FL\cos a = \pm(P+p)h+RL+\frac{f\rho L}{r}\sqrt{F^2+P^2-2\,Fp\sin(a+i)}$$

and $$R = F \cos \alpha \pm (P+p)\frac{h}{L} - \frac{f\rho}{r}\sqrt{F^2+P^2-2\,Fp\sin(\alpha+i)}$$

The effect of the last term in this equation is very small; it attains its highest value when $(i)=0$, but usually $\tan \alpha = 0{\cdot}262$, $\sin \alpha = 0{\cdot}255$, $\frac{\rho}{r} = 0{\cdot}02$, and $f = 0{\cdot}065$.

Substituting these values in the equation, it will always be found that the friction of the axle is less than 1/50 to 1/100 of the tractive force.

Now, neglecting the last term and making $\cos \alpha = 0{\cdot}967$, the formula is reduced to the expression—

$$R = 0{\cdot}967\ F \pm (P+p)\frac{h}{L}$$

The values of h, L, P, and p are known, and the dynamometer gives F; the resistance R can then be determined. Representing R by an ordinate to a given scale, rectangular axes ox and oy can be chosen; if from the axis x the values of the element which varies—*i.e.*, the weight $(P+p)$—be marked off, and at the extremity of each of these values an ordinate corresponding to the value of R be raised, then a number of points can be determined lying on a curve, and from the form of the curve can be found the law which governs the ratio between the resistance R and the variable element.

The preceding formulæ only apply to traction upon level roads.

The following are the conclusions drawn from General Morin's first series of experiments:—

I. 'The resistance to traction on macadam or paved roads (taken relatively to the axle parallel to the ground) is proportional to the pressure and inversely proportional to the radius of the wheel.

II. 'The deterioration of the road due to the vehicle increases as the wheels decrease in diameter.'

III. 'The resistance is very nearly independent of the width of the tyres on macadam or paved roads for sizes above 0·08 m. to 0·10 m. in width.'

IV. 'On compressible roads, such as loose earth, sand, gravel, and new macadam, the resistance to traction decreases as the width of the tyre increases; the proportion depends upon the condition of the road. On hard roads it is useless to employ wide tyres, and on macadam in the ordinary state the tyres should not be wider than 0·10 m. to 0·12 m.'

V. 'On soft ground, such as soil, sand, earth driftways in good condition, rutty roads, or layers of gravel on hard ground, the resistance is independent of the speed of the vehicle with or without springs.'

VI. 'At a walking-pace on all roads the resistance is practically the same for all vehicles.'

VII. 'On macadam or paved roads the resistance increases with the speed.' The rate of increase of resistance is nearly in proportion to the increase in speed, with an initial speed of 1 m. per second. The less rigid the vehicle, the better the springs of the vehicle; and the more uniform the road, the less will be rate of increase of resistance.

VIII. 'On good sandstone pavement, well laid and uniform, the resistance at walking-pace is only three-quarters of that on the best macadam; and for vehicles well hung, the resistance at trotting-pace on good pavement is equal to the resistance on good macadam. But on bad pavement, with the setts too far apart, the resistance at trotting-pace is more than that on good macadam, even with vehicles with the best springs.'

IX. 'The inclination of the line of draught, for the maximum useful pull, increases with the resistance due to the surface of the road and as the diameter of the fore-wheels diminishes. On the ordinary road the inclination tends to the horizontal, so much as the construction of the vehicle will permit.'

These preceding facts were not always borne out by the experiments conducted by General Morin, so he was requested by the Minister of Public Works to undertake a further series of experiments in order to set at rest the following questions :—

I. Is the deterioration of the surface of the roads in inverse ratio to the width of the tyres, with equally weighted vehicles?

II. Can vehicles be loaded proportionally to their width of tyres?

III. Is the deterioration of the road in inverse ratio to the diameter of the wheels?

IV. Can vehicles be loaded in proportion to the diameter of the wheels?

V. Which causes more damage to the road, a light dog-cart or a country cart, both equally loaded?

VI. What is the rate of deterioration of roads in different states of repair?

After a further series of experiments he replied as follows :—

(i.) To say that it is legitimate to weight vehicles proportionally to their width of tyres, assumes the hypothesis that the tyre presses equally upon the ground throughout its whole width, which is not a correct basis.

(ii.) Equally weighted wheels with tyres 0·06 m. in width deteriorate the roads more than those with tyres 0·115 m. to 0·165 m. There is no marked difference from 0·115 m. to 0·165 m. in width, so about 0·115 m. is the maximum.

(iii.) A four-wheeled vehicle (waggon) with tyres 0·060 m. in width, diameter of fore-wheels 1·3 m., diameter of rear-wheels 1·5 m., can be loaded up to 2,400 kilos in dry weather and 1,800 kilos in the rainy season.

(iv.) Vehicles equally loaded, and with the same width of tyre, deteriorate the road more as their diameter is decreased within certain limits. The least diameter of the fore-wheels of a waggon should be 1 m. if it will allow them to turn under the frame. This limit is fixed upon in order not to raise the centre of gravity too high. The diameter of the wheels can be decided upon with due consideration to the centre of gravity and position of axle and frame.

(v.) A load of 2,465 kilos drawn by a vehicle with tyres 2·029 m. in diameter and in width 0·115 m., on a good macadam road, does not cause any appreciable damage to the roads, even if the road be wet on the surface. But a load of 5,000 kilos drawn on a cart with wheels 1·83 m. in diameter and tyres 0·165 m. wide, or a load of 7,985 kilos drawn on a four-wheeled waggon with tyres 0·16 m. wide and fore-wheels 1·011 m. and rear-wheels 1·73 m. in diameter respectively, produces a considerable deterioration upon the road. Therefore the load should not exceed 3,500 to 4,000 kilos.

(vi.) A load of 1,800 kilos on a cart with tyres 0·06 m. in width, on a good macadam road with a wet surface, causes considerable deterioration to the roadway; therefore the maximum load under these conditions should not exceed 2,000 kilos, unless their tyres exceed 0·07 m. in width.

(vii.) The distribution of a load on two or more vehicles, producing a distribution of the pressure over a larger surface, causes less damage to the road.

(viii.) A load of 8,000 kilos on a macadam road with a wet surface causes considerable damage, and this limit ought to be considerably reduced if the roads are to be kept intact.

(ix.) A spring carriage going at a trotting-pace with loads of 5,000 kilos on macadam roads with wet surfaces does not cause any more damage than the same vehicle without springs proceeding at a walking-pace.

(x.) The best limit to fix for the fore-wheels of waggons is 1 to 1·10 m., and for the rear-wheels 1·50 to 1·60 m., in accordance with the construction of the vehicle.

The following table gives the results (after General Morin) of the relation between the tractive effort and the total load for different kinds of roads and vehicles:—

General Morin's Table for the Ratio of Tractive Force and Total Load.

Description and State of Roads	Artillery Waggons	Goods Waggons	Carts	Coaches and Carriages with Springs
Turf, softened by melting snow	$\frac{1}{8}$	—	—	—
„ firm	$\frac{1}{20}$	—	—	—
„ very dry	$\frac{1}{24}$	—	—	—
Earthways in good condition, dry, &c.	$\frac{1}{30}$	$\frac{1}{27}$	$\frac{1}{40}$	$\frac{1}{26}$
Earth road, covered with untrodden snow.	$\frac{1}{16}$	$\frac{1}{15}$	$\frac{1}{21}$	$\frac{1}{13}$
Firm earth, with a bed of sand or gravel 0·1 to 0·15 m. in thickness.	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{12}$	$\frac{1}{4}$
Macadam, dry and uniform	$\frac{1}{54}$	$\frac{1}{50}$ to $\frac{1}{58}$	$\frac{1}{66}$ to $\frac{1}{82}$	$\frac{1}{47}$ walking. $\frac{1}{40}$ trotting.
„ wet and dusty, projecting stones.	$\frac{1}{38}$	$\frac{1}{33}$ to $\frac{1}{41}$	$\frac{1}{47}$ to $\frac{1}{58}$	$\frac{1}{33}$ walking. $\frac{1}{25}$ trotting.
„ firm, slight wear, and soft mud.	$\frac{1}{30}$	$\frac{1}{27}$ to $\frac{1}{31}$	$\frac{1}{36}$ to $\frac{1}{45}$	$\frac{1}{26}$ walking. $\frac{1}{20}$ trotting.
„ firm, with ruts and very muddy.	$\frac{1}{24}$	$\frac{1}{22}$ to $\frac{1}{25}$	$\frac{1}{29}$ to $\frac{1}{36}$	$\frac{1}{21}$ walking $\frac{1}{17}$ trotting.
„ worn and covered with thick mud.	$\frac{1}{20}$	$\frac{1}{18}$ to $\frac{1}{21}$	$\frac{1}{25}$ to $\frac{1}{31}$	$\frac{1}{18}$ walking. $\frac{1}{15}$ trotting.
„ badly worn and rutty, mud very thick.	$\frac{1}{16}$	$\frac{1}{14}$ to $\frac{1}{18}$	$\frac{1}{19}$ to $\frac{1}{25}$	$\frac{1}{15}$ walking. $\frac{1}{11}$ trotting.
„ very badly worn, and with deep ruts, hard foundation, and unequal surface.	$\frac{1}{14}$	$\frac{1}{12}$ to $\frac{1}{15}$	$\frac{1}{17}$ to $\frac{1}{21}$	$\frac{1}{13}$ walking. $\frac{1}{10}$ trotting.
Sandstone roads, well set, and closely laid.	$\frac{1}{76}$	$\frac{1}{64}$ to $\frac{1}{75}$	$\frac{1}{88}$ to $\frac{1}{107}$	$\frac{1}{62}$ walking. $\frac{1}{35}$ full jog.
Roads paved with Fontainebleau sandstone, dry.	$\frac{1}{65}$	$\frac{1}{59}$ to $\frac{1}{68}$	$\frac{1}{80}$ to $\frac{1}{100}$	$\frac{1}{57}$ walking. $\frac{1}{38}$ trotting.
Paved roads, wet, and covered with mud.	$\frac{1}{50}$	$\frac{1}{46}$ to $\frac{1}{53}$	$\frac{1}{61}$ to $\frac{1}{78}$	$\frac{1}{44}$ walking. $\frac{1}{33}$ trotting.
Timber flooring of a bridge	$\frac{1}{40}$	$\frac{1}{42}$ to $\frac{1}{45}$	$\frac{1}{41}$	$\frac{1}{41}$ walking. $\frac{1}{41}$ trotting.

Below is General Morin's table for the maximum load that can be drawn on a level road.

Class of Vehicle	Winter	Summer
Country cart, with 1 horse . . .	1,800 kilos	2,000 kilos
Four-wheel vehicle, with 2 horses . .	2,400 ,,	2,800 ,,
,, ,, 4 horses . .	4,800 ,,	5,200 ,,
,, ,, 6 horses . .	7,200 ,,	9,100 ,,
Cart, with 1 horse	1,800 ,,	2,500 ,,
,, 2 horses	3,500 ,,	4,000 ,,
,, 3 horses	4,500 ,,	5,000 ,,

General Morin's experiments decided for the time being the dimensions of the wheels and the maximum loads that vehicles should be allowed to carry. He strongly recommended the erection of weighing machines on all the principal thoroughfares.

V. *The Researches of M. Dupuit.*

General Morin's experiments were fully accepted by the scientific world; they were, however, fiercely attacked by a civil engineer, M. Dupuit, who, after much experimenting, arrived at formulæ which differed considerably from those of Morin.

M. Dupuit pointed out a number of errors in the calculations given in Morin's tables, and leads us to suppose that these suggest many others in Morin's preliminary calculations, of which the results only are shown in the tables.

He states that the figures obtained differ considerably from those that give the proportion of the load to the diameter of the wheel; that General Morin commits a serious error in his value for axle friction, i.e., $f.=0{\cdot}05$, which is too small and ought to be 0·12. That the distance travelled per revolution ought to be calculated from the diameter of the interior of the nave, as there is considerable play between the axle and the nave. That for the proportion of the tractive effort to the diameter of the wheel Morin compares experiments taken under various conditions, which removes all certainty from his results. That in Morin's experiments on the width of tyres, the pressure and width of tyre are varied at the same time, so that it is impossible to distinguish the part played by each in the experiments.

After pointing out these errors in General Morin's experiments, Dupuit proceeded to conduct experiments exactly similar, but with his own apparatus, which was attached to a special car and had the advantage that experiments could be performed more quickly, as the vehicles to be tested had only to be attached to the dynamometer coupling on the special car.

Dupuit experimented on the resistance to rolling of cylinders, by placing at the top of an inclined plane wheels which were allowed to roll down and run along the level until they were brought to a state of rest by the frictional resistance.

If h = height of incline; P = weight of wheel; S = distance travelled along incline and level; R = resistance to rolling, then resistance offered to the weight P will be PR. The work due to resistance will be PRS, and the equation of work which equalises the work done by the weights to the work of resistance will be

$$Ph = \text{RPS} \qquad \text{or } R = \frac{h}{S}$$

Taking the square root of the diameter D of the cylinders, and obtaining the product $R\sqrt{D}$, Dupuit found that it always gave a constant number, which proved that the resistance to rolling varies in inverse ratio to the square root of the diameter, and not as the first power, as stated by Morin and Coulomb.

M. Dupuit concludes from his experiments that on uniform surfaces generally, as macadam :

(1) The tractive effort is proportional to the load.
(2) " " independent of the width of tyres.
(3) " " inversely proportional to the square root of the diameter of the wheels.
(4) " " independent of the velocity.

That the tractive effort or horizontal force necessary to move a vehicle on the level is expressed by the formula

$$T = \rho \frac{\sqrt{2R}}{P}$$

P = weight of vehicle; ρ = a constant which expresses a ratio between the compressibility and elasticity of the surface.

The constant ρ is found from the formula

$$\rho = \frac{3}{8} \frac{\epsilon}{\sqrt{\epsilon'}}$$

in which ϵ is the instant compression of the ground, and ϵ' the permanent set due to the load.

On paved roads, Dupuit recognised that the formula had to be modified, for although the force required is always proportional to the load and to the square root of the diameter of the wheels, yet it increases with the speed, and diminishes as the width of tyre diminishes within certain limits, and also that springs diminish the force required, whereas on macadam springs have very little influence.

Dupuit's Table for the Ratio of Tractive Force to Load.

Class of Vehicle	Diameter of Wheels	Width of tyres in metres	Ratio of tractive force to pressure on		
			Macadam. Walking or trotting	Paved Roads	
				Walking	Trotting
Cart	1·82	·05	·032	·012	·028
Rubbish cart . .	1·85	·075	·031	·0205	·028
" " . .	1·89	·11	·03	·0176	·028
" " . .	1·90	·14	·03	·0166	·028
Gig	1·48	·05	·036	·024	·034
Carriage . . .	1·96	·17	·029	·0177	·028
Char-à-banc . .	1·50	·05	·036	·03	·037
" . . .	0·86	·05	·036	·03	·037
Coach	1·5	·13	·029	·016	·02
"	0·95	·13	·029	·016	·02

Dupuit found that the mean force required to draw a vehicle loaded up to 1,000 kilos was

On macadam roads	= 30 kilos
On paved roads	= 20 kilos

That on flagstones perfectly dressed the tractive force required equals 6 kilos per ton, and that on asphalte equals about 10 kilos per ton. From the above he obtained the following ratio :—

The resistance on railroads : the resistance on pavements : the resistance on macadam :: 1 : 4 : 6 ; but these resistances are not in proportion to the respective roughnesses, which are as 1 : 15 : 36.

M. Dupuit performed experiments on the effect of the width of tyres, and carefully noticed the manner in which they wore. He found that the edges became furrowed into deep grooves, and that some particles of the stretched iron became detached ; also that the wood having at first a rectilinear section was found after being considerably used to be elliptical.

Experiments were made with wide tyres, and it was found that for a tyre 17 cm. in width only 9 cm. were in actual contact, and 6 cm. of a 14 cm. tyre ; from this he concluded that the length of contact is of more importance than the width, this being at least 14 cm. for a tyre 2 m. in diameter ; that wide tyres are only useful when they bear on the road throughout their whole width, and in cases when the road is soft, uneven, and in a bad condition.

Dupuit states that from actual experiments he found that a tyre of 17 cm. after a few weeks' wear was reduced to 14 cm. and after a few months' to 11 cm., and that after a 17 cm. tyre had been run 4,000 miles it was worn out and showed a loss of 1 kilo for every 20 miles and per ton of useful load carried.

And, moreover, since the tyre is rounded, it is necessary to admit that the pressure is unequal throughout its whole width, and that not only does it diminish on both sides of the centre but to the right and left, that the surface in contact is not square or rectilinear in section but elliptical, forming an ellipse the major axis of which increases far more rapidly with the diameter of the tyre than the minor axis increases with the width of tyre.

From another series of experiments Dupuit proved that under a pressure of 2,000 kilos, scarcely $\frac{1}{16}$ of the material of the road was subjected to any strain. From this he concluded that 4,000 kilos might be taken as a standard load for a two-wheel vehicle, and the weighting distributed as follows :—

Wheels (one pair) . . .	600 kilos
Axle and frame . . .	520 „
Useful load	2,880 „
	4,000 kilos = Total load

Dupuit on the Effect of Hollows and Rises in Roads.

Dupuit obtained the following formulæ :—

$$\theta' = \theta \sqrt{\frac{1}{1 - \frac{R}{R}}} \text{ and } \theta'' = \theta \sqrt{\frac{1}{1 + \frac{R}{R}}}$$

in which

Θ = tractive force on the level
Θ' = „ „ in a hollow
Θ'' = „ „ on a rise
R = Radius of the wheel.
R_1 = Radius on surface of the road, either concave or convex.

By giving different values to R_1 in reference to R, Dupuit found that the hollows have the effect of increasing the pull to a large extent, and their influence has a greater effect as the diameter of the wheel increases, and that the rises had the effect of decreasing the pull; but that the increase was always greater than the decrease.

From experiments Dupuit concluded that, providing the road was undulating and had no very sudden rises or depressions, the effect of the undulations was practically *nil*.

VI. *Theoretical Investigations of Edmund Leahy, C.E.* (1847).

In an exhaustive treatise on 'The Making and Repairing of Roads' Mr. Leahy states that the power required to move a car upon a level road depends upon the friction of the axles and the resistance to rolling. The friction of the axles is the same in nearly all cases, as long as the load and the car are the same; but the resistance to rolling, having its immediate action at the tyre, must be variable according to the description of road upon which the wheels move.

He proves that the friction at the axle can be represented by the following formula :—

$$P=W\frac{d}{2r}\tan A \quad . \quad . \quad . \quad . \quad (1)$$

where P is that force applied at the tyre which is just sufficient to rotate the wheel when supported on its axle, where W is the load on the axle, *d* the diameter of the axle, 2*r* the diameter of the wheel, and where A is the limiting angle of resistance for the surfaces in contact.

He then goes on to consider the resistance to rolling, which may be due to either or both of two causes—namely, irregularity of surface, or yielding of surface over which the vehicle passes.

Dealing with irregularity of surface first, he obtains a formula for the initial effort required to surmount an obstacle.

The formula is

$$P=W\frac{\sqrt{2rh-h^2}}{r-h} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where P is the tractive effort required, *r* is the radius of the wheel, W is the load on the wheel, and *h* is the height of the obstacle. He further proves that when the tractor, be it horse or motor, is unable to exert this initial effort, the minimum velocity which the vehicle must have to surmount the obstacle is given by

$$V=\sqrt{2g}\,\frac{r}{r-h}\left\{h-\frac{P}{W}\times\left(\begin{matrix}\text{length of arc described by centre of}\\ \text{wheel in passing over the obstacle}\end{matrix}\right)\right\} \quad . \quad (3)$$

V is the least velocity which, together with the draught P, will enable the vehicle to mount the obstacle.

Here he deals with the loss of energy in mounting obstacles, and shows that this loss is given, when h is small, by the following :—

$$\text{Loss of energy} = \frac{WV^2}{g} \times \frac{2h}{r} \quad . \quad . \quad . \quad . \quad (4)$$

This is lost while the vehicle is moving a distance $=2l$, say, and hence he shows that the average effort is given by

$$\text{Average effort} = \frac{WV^2}{gr} \frac{\sqrt{h}}{\sqrt{2r-h}} \quad . \quad . \quad . \quad . \quad (5)$$

He concludes from these formulæ that the draught on a road whose surface presents a number of unyielding and projecting obstacles varies directly as the square of the velocity, and inversely as the square root of the cube of the size of the wheel. He goes on to say that the draught upon irregular surfaces must be much more than that which has been ascertained, in all cases where the velocity of motion is considerable, because there is no substance perfectly inelastic, and therefore, after striking the obstacle, the wheel will rebound backwards from the obstacle with a velocity proportionate to the relation between the forces of impact and restitution referable to the elasticities of the wheel and the material of the obstruction ; moreover, the obstacle when struck will, in many cases, slide to some extent, and thereby weaken the momentum.

He then deals with the tractive effort required for a yielding surface, and states that to a great extent resistance to rolling is due to a continual displacement of a portion of the road material owing to its inelasticity, which, while it allows that material to exert a pressure against the fore-part of the wheel, will not permit it to rise behind, and thereby propel the wheel by its reaction. Thus the draught upon a soft surface is much greater than if it were upon a hard, unyielding surface.

He then deduces a formula for the draught upon soft surfaces, making two assumptions : first, that surface of road is perfectly inelastic ; and secondly, that the resistance to compression varies simply as the depth compressed.

Using the same notation as before, except that h is now the depth to which the wheel sinks, the formula is

$$P = \frac{Wh^2}{\text{Area immersed}} \quad . \quad . \quad . \quad . \quad (6)$$

or further

$$P = \frac{3\,W}{8} \times \frac{\text{Length immersed}}{\text{Diameter of wheel}} \quad . \quad . \quad . \quad (7)$$

and hence he shows that the draught varies inversely as the cube root of the square of the size of the wheel, or little more than the inverse of the height of the wheel.

He then proceeds to prove that when R is the angle of friction of rolling, A the angle of friction for the surfaces in contact at the axle, d the diameter of the axle, and $2r$ the diameter of the wheel

$$P = W \frac{\sin R + \tan A \frac{d}{2r}}{1 - \sin R \tan A \frac{d}{2r}} \quad . \quad . \quad . \quad . \quad (8)$$

He remarks that the deductions of M. Morin are in perfect accordance with the previous theoretical investigations, and alludes to the Second Report of the Select Committee of the House of Lords (1833) upon Turnpike Road Trusts, where Mr. Macneill has given the following empirical formula for the draught on common roads :—

$$P = \frac{W + w}{93} + \frac{w}{40} + cV.$$

where W is the weight of waggon, w is the load, V the velocity in feet per second, and c a constant, which depends on the surface over which the waggon is drawn.

Mr. Macneill ascertained the value of c for different surfaces as follows :—

$c = 2$ for a timber surface.
$c = 2$ for a paved surface.
$c = 5$ for a well-made broken stone road in a dry state.
$c = 8$ for the like surface covered with dust.
$c = 10$ for the same wet, and covered with mud.
$c = 13$ for a gravel or flint road when wet.
$c = 32$ for the same, very wet and covered with mud.

Leahy then compares the theoretical investigation with experiment, showing in the first place that both agree that springs do not diminish the draught when the motion is so slow as to permit the body of the vehicle to be elevated and depressed just as much as the axle. The fact that the draught over an even, soft surface is not affected by the velocity corresponds with the experiments of M. Morin, but is at variance with the views of Mr. Macneill.

By equation (4) he shows that over hard, irregular surfaces the variation of the draught is as the square of the velocity, and remarks that there is a seeming discrepancy between this conclusion and the results of experiments made under apparently analogous hypotheses, which would regulate the increments of traction by proportional increments of velocity.

It must be remembered, however, that the experiments of M. Morin and others were made upon roads said to be hard, yet not so in fact, and with elastic machines, whereas had the experiments been conducted upon a perfectly unyielding surface and with a rigid and inelastic machine there is no doubt that the draught would vary as the square of the velocity, and therefore the conclusion is arrived at that according as the machine and rough roadway approach a state of inelasticity the more nearly will the draught correspond with this law of variation. Every road presents a different description of surface, and if upon one the draught was not at all affected by the velocity, or varied as V^0 owing to its softness and regularity, and upon another it varied as V^2 owing to its hardness and roughness, surely as there are many intermediate descriptions of surface between these extremes, so also must the draught upon them vary, as some intermediate power, between 0 and 2 of the velocity. Therefore, in general, the resistance to rolling must vary as V^n, in which n is the constant suitable to each particular surface, and always lying between 0 and 2; and any accurate empirical expression for the draught upon roads must have V^n as one of its terms.

He then goes on to consider the uniformity of draught, deducing a formula

$$P = W \cos a \, (\tan R + \tan A \frac{d}{2r}) + W \sin a$$

for the draught upon an acclivity in which a is the angle of ascent and R the angle of friction of rolling corresponding to any description of surface. Comparing this last equation with that for the draught upon a level road—

$$P = W \, (\tan R + \tan A \frac{d}{2r}) \text{ nearly—}$$

he concludes by drawing up the following table of uniform draught :—

Table of Uniform Draught.

Description of Surface	Rate of Inclination
Ordinary broken stone surface	Level
Close firm stone paving	1 in 48¼
„ timber paving	1 in 41½
„ „ trackway	1 in 31⅘
„ cut stone trackway	1 in 31⅗
„ iron tramway	1 in 29¼
„ „ railway	1 in 28⅓

VII. *The Work of M. Charié-Marsaines.*

M. Charié-Marsaines, inspector of roads and bridges, being struck by the instinctive preference of the farmers in the department Du Nord for paved road, undertook a series of experiments in order to compare paved and macadam roads, as to durability, cost of maintenance, and the maximum load capable of being supported.

Below are the results of his experiments :—

Season	Description of roads	Load per horse	Distance run per hour	Work per hour in kilogrammetres	Ratio
Winter	Paved	1·306	3·300	4,309,800	1·644
	Macadam	·851	3·080	2,621,080	
Summer	Paved	1·395	3·500	4,882,500	1·229
	Macadam	1·141	3·480	3,970,680	

The results of Charié-Marsaines' researches are as follows :—

(i.) The wear on the harness is less on paved than on macadam roads.

(ii.) The wear and tear on the vehicles is greater.

(iii.) The lasting power of the horse is much less on macadam roads. A harness lasts six years on paved roads and five on macadam. A vehicle lasts seven years on paved roads and nine on macadam.

These results differ very little from those given by Schwilgué in his experiments performed in 1832 on the roads between Paris and Havre.

VIII. *Experiments by A. Michelin* (1896).

Series of Five Tests made by A. Michelin.

General data for five series of tests were as follows :—

Diameter of iron wheels .	front 0·92 m. .	back 1·12 m.
,, ,, pneumatic wheels .	,, 0·90 m. .	,, 1·20 m.
Weight of iron wheels . .	,, 58 kg. .	,, 72 kg.
,, ,, pneumatic wheels .	,, 39 kg. .	,, 56 kg.
,, ,, brake, empty, iron wheels		. 577 kg.
,, ,, ,, ,, pneumatic wheels		. 542 kg.

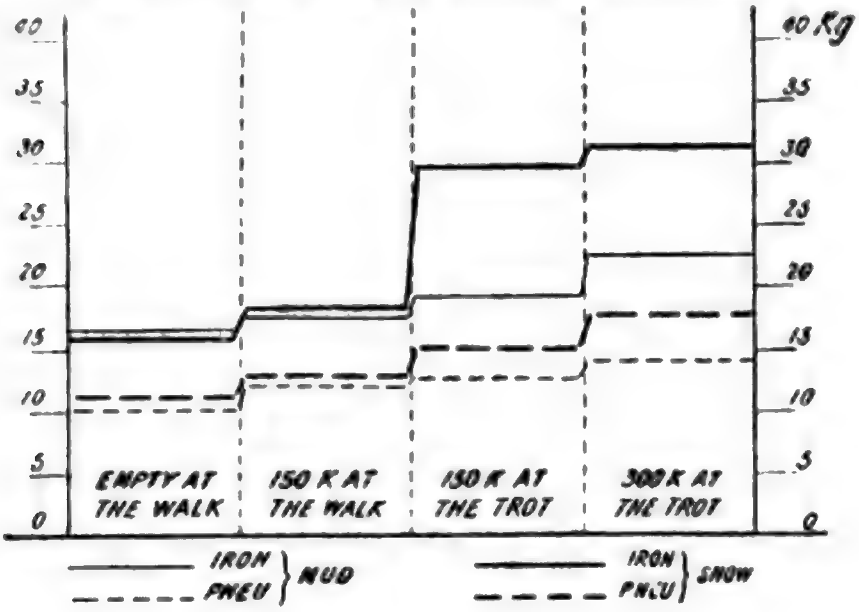
Snow Trial on January 5, 1895.

—	Iron wheels	Pneumatics
	kg.	kg.
Empty carriage (walking)	15·86	11·47
Loaded ,, 150 kg. ,, ...	17·83	12·71
,, ,, ,, (trotting)	29·60	15·27
,, ,, 300 kg. ,, ...	31·17	17·96

Mud Trial on January 25, 1895.

—	Iron wheels	Pneumatics
	kg.	kg.
Empty carriage (walking)	16·00	10·50
Loaded ,, 150 kg. ,, ...	17·39	12·43
,, ,, ,, (trotting)	19·55	12·97
,, ,, 300 kg. ,, ...	23·06	14·16

FIG. 1.—First Series of Trials (January 1895).



Second Series of Tests, August 1895.

Instead of taking the same running ground (as on the first trials) on the various days, different surfaces were tried under the same conditions of dryness.

Average for the whole of the Runs.

——	Pace	Iron wheels	Pneumatic wheels	If traction of pneumatic = 100 then iron =
		kg.	kg.	
Empty carriage	Walking	17·42	14·05	124
„ „	Trotting	20·41	15·95	128
Heavily loaded, 300 kg.	Walking	20·75	16·11	128·5
„ „ „	Trotting	29·70	16·40	181

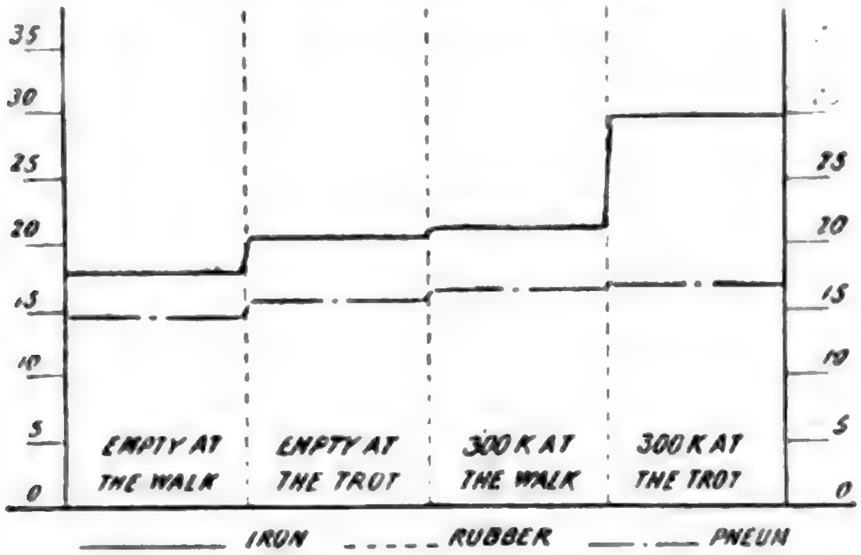
From the above and fig. 2 the advantage of the pneumatic is evident. It is considerably augmented with the speed and the load.

General average obtained for all roads, at all speeds and loadings :—

For iron-shod wheels	22·07 kg.
„ pneumatic „	15·63 kg.

Michelin found that even upon hard and smooth ground, pneumatic tyres gave a greater economy, amounting to about one-third.

FIG. 2.—Second Series of Trials (August 1895).



Third Series of Tests, November 1895.

More variety in the nature of the roads.

Three trials over each kind of road :—

(*A*) Total length, 40 m. ; gradient, 1·5 per cent. ; macadam, fairly good, less sound than second series.

(*B*) Total length, 110 m. ; good regular pavement ; gradient, 1·2 per cent.

(*C*) Badly paved, irregular ; gradient, 1·9 per cent. ; length, 50 m.

(*D*) Steep gradient, 5·8 per cent. ; macadam, in good condition ; length, 80 m.

(*E*) Road through vineyards very badly maintained ; length, 50 m.

Experiments made at the trot, &c.

Now, if we take the average of all these speeds over the three Courses *A*, *B*, and *C*, we have[1]

——	Iron wheels	Pneumatics	Solid indiarubber
	kg.	kg.	kg.
Empty carriages at the trot	20·81	15·45	20·07
Heavily loaded, 300 kg., walking . . .	22·10	19·87	25·69
Heavily loaded, 300 kg., at the trot . . .	29·52	20·65	28·62

Walking and trotting.
If traction pneumatics = 100
Then traction of iron wheels = 129·4
Traction of solid rubber „ = 132·8

Trotting alone.
Traction for pneumatics = 100
„ „ iron wheels = 134·9
„ „ solid rubber = 139·6

FIG. 3.—Third Series of Trials (November 1895).

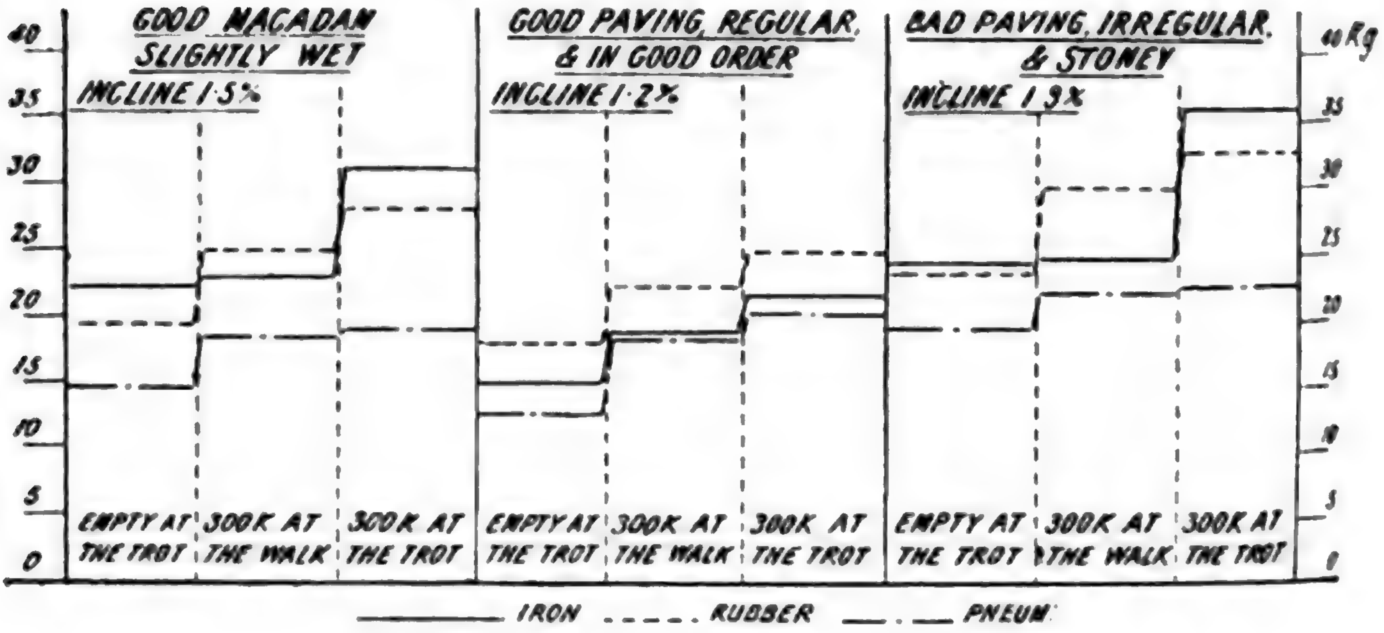
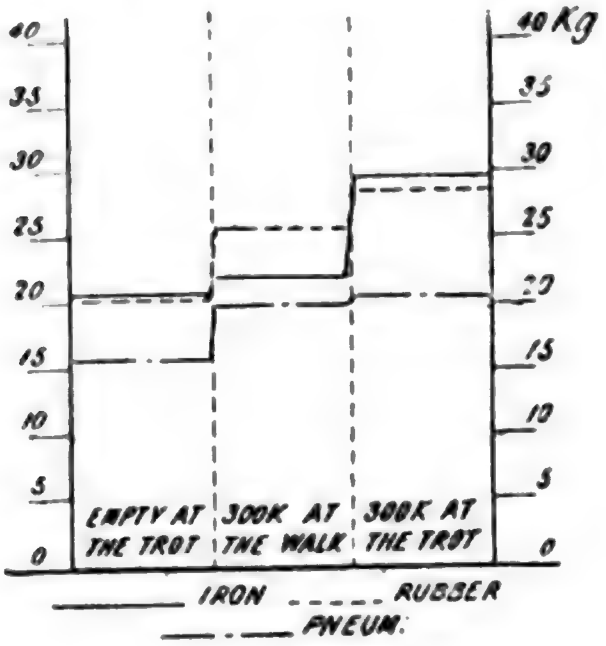


FIG. 4.—Third Series (*Résumé*).



Third Series of Tests, November 1895.

—	Empty carriage at the trot			Load, 300 kg., at the walk			Load, 300 kg., at the trot		
	Iron	Pneus.	Solid	Iron	Pneus.	Solid	Iron	Pneus.	Solid
	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.	kg.
Course A. Macadam, fairly good condition, slightly damp. Gradient, 1·5 per cent. . . .	22·38	14·34	19·22	22·88	18·79	25·03	31·12 (?)	18·9	28·25
Course B. Good regular pavement, dry and clean. Gradient, 1·2 per cent. .	14·83	12·53	17·80	18·89	18·68 (?)	22·12	21·30	20·50 (?)	24·90
Course C. Bad, irregular pavement, flinty D'Allier. Gradient, 1·9 per cent.	24·39	19·49	23·20	24·53	22·16	29·92	36·13	22·55	32·70
Course D. Macadam in good condition. Gradient, 5·8 per cent.	—	—	—	47·73	46·81	49·58	—	—	—
Course E. Macadam, badly kept, wheel ruts. Gradient, 5 per cent. . . .	—	—	—	83·69	56·64	77·91	—	—	—

The results of these tests (shown in fig. 4) only go to confirm the two previous series of tests, and markedly show the worse the ground the greater the economy in using pneumatics. Tests were not taken with iron wheels over Courses *D* and *E*, on account of the great shocks destroying the instruments.

Fourth Series of Tests, January 1896.

In the previous experiments errors crept into the results, but this series clears them away.

The normal speed was about 10·5 km. per hour.

Fourth Series of Tests.

Speeds at the trot, 10·50 km. per hour.		Pneus.	Iron	Solid
		kg.	kg.	kg.
(A) Pavement tolerably regular. Gradient 1·8 per cent.	1st. Dry, frosty . .	19·4	25·9	25·4
	2nd. Liquid mud, slightly sticky.	21·65	29·6	28·3
	3rd. Same mud, dried .	20·25	27·2	26·4
(B) Old macadam, slightly damaged. Gradient 1·8 per cent.	1st. Dry, frosty . .	20·6	22·8	24·8
	2nd. Liquid mud, slightly sticky.	23·2	31·7	29·2
	3rd. Same mud, dried .	22·4	28·16	27·5
(C) Good regular pavement. Gradient 1·2 per cent.	1st. Dry	14·8	18·2	18·8
	2nd. Wet	16·1	19·8	21
(D) Bad and irregular pavement. Gradient 1·9 per cent.	1st. Dry	19·4	29·1	27·8
	2nd. Wet	22·2	32·4	29·7

If we take 100 as the power necessary to draw the vehicle with pneumatics, then we get :—

On good pavement with mud slightly sticky	Pneumatics	= 100
" " " " "	Iron wheels	= 136·7
" " " " "	Solid rubber	= 130·7
Upon bad pavement, dry	Pneumatics	= 100
" " "	Iron wheels	= 150
" " "	Solid rubber	= 143
Good regular pavement, dry	Pneumatics	= 100
" " " "	Iron wheels	= 123
" " " "	Solid rubber	= 127

These results again show the great advantage of pneumatic tyres in all cases.

FIG. 5.—Fourth Series of Trials (January 1896).

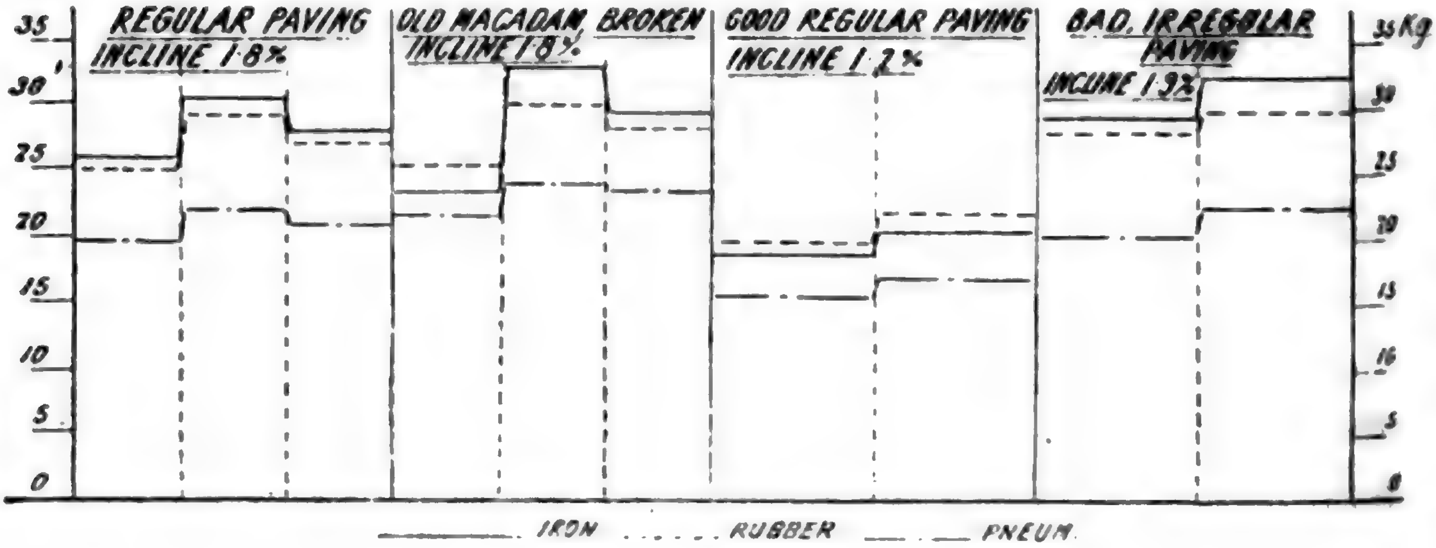
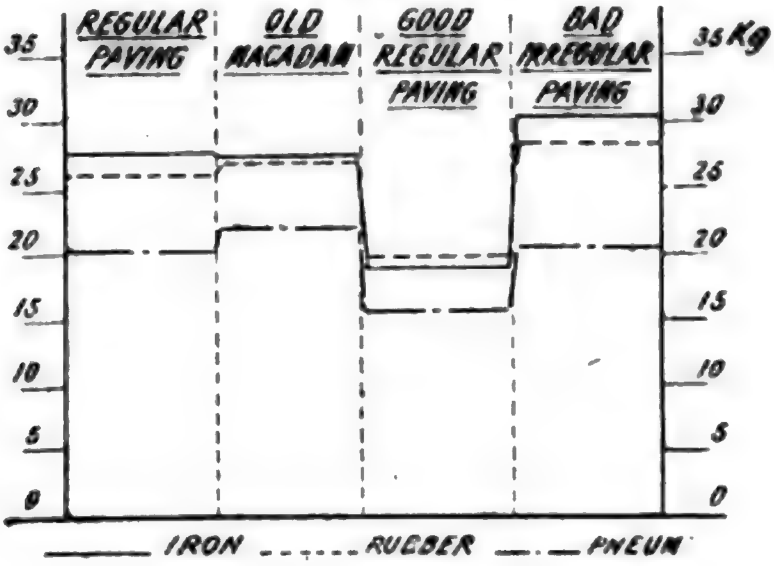


FIG. 6.—Fourth Series (*Résumé*).



Fifth Series of Tests, February 1896.

All the tests hitherto have shown that the economy of pneumatics was more apparent at the trot than at the walk. It can even be said that the force taken by the pneumatic increased but little as the speed went up from walking to trotting, whilst that absorbed by the iron perceptibly increased with the speed.

Experiments were made on a good regular macadam road; length 100 m., gr. 1·5 per cent. Each test was repeated several times with an empty vehicle, from which were deduced the following average speeds :—

For pneumatics . 4·900 km. per hour = walking speed; 10·5 = trotting; 15·12 = quick trot.
For iron . . . 4·550 km. per hour = walking speed; 10·94 = trotting; 15·12 = quick trot.

The averages of the forces exerted were as follows :—

—	Walking	Trotting	Quick trotting
For pneumatics . .	13·0 kg.	13·5 kg.	13·5 kg.
For iron wheels . .	13·8 kg.	17·0 kg.	22·1 kg.

It will be noticed that at the trot and quick trot the results for pneumatics are the same. It appears then that whatever the speed may be within reasonable limits, the force absorbed by traction varies but little upon good ground with pneumatic tyres.

Then the advantage of the pneumatic over the iron tyres increases with the speed. If we take 100 as the pneumatic traction, we obtain for the iron traction at the ordinary trot 126; at quick trot 164.

The following conclusions can be drawn from the above experiments :—

(i.) The solid indiarubber tyre is better than the iron in certain cases, especially if the road be sticky, very irregular, or covered with snow, but it becomes inferior to iron if the surface be hard and smooth.

(ii.) Solid tyre vastly inferior to the pneumatic.

(iii.) Pneumatic 50 per cent. better than the iron.

Michelin compared his experiments with those of General Morin by making a series of complementary tests with iron wheels upon good dry pavement as much like the conditions under which General Morin's experiments were performed as possible, with results as follows :—

Walking = 12·9 kg.
Trotting = 8·8 kg

These, on being compared with General Morin's, will be found in every case below those given by him; this is owing evidently to the better hanging of the vehicle and the better dynamometer.

But if we compare these various forces, taking for example 100 as the force of traction at walking pace, we arrive at the following results :—

—		Force calculated after Morin	Average force from above experiments
1st Case.—Upon macadam in good condition, dusty	Walking	100	100
	Trotting	127	123
	Quick trotting	152	160
2nd Case.—Good dry pavement	Walking	100	100
	Trotting	151	146

The results are almost identical with those of General Morin.

IX. *Extract from the Report of Professor W. C. Unwin, F.R.S., on the Trials of Self-moving Vehicles at Birmingham made before the Royal Agricultural Society*, 1897.

Some experiments were made on the competing vehicles to determine the vehicle friction.

The method adopted was to allow the cars to run down hill by gravity (the motor being idle) and noting the speed acquired and the distance in which they came to rest.

The cars, fully loaded, were taken to a hill on the road between Bassett's Pole and Bonehill. This portion of the road was levelled and marked out in 100-foot distances.

The total weights of the cars and loads in these trials were the following :—

Daimler	2·43 tons.
Lancashire	6·49 „
Chiswick	6·57 „

Method of Trials.—Each car was brought to one of the marked distances on the descending gradient, generally the point 300 feet from A, but in Trial 3 at 400 feet from A. The car was then gently started from rest and allowed to descend the hill by gravity. As it passed over the 200-foot length from B to C the time of passage was taken. The car was allowed to come to rest, stopping generally at a point beyond C, but in two trials a little short of C. From the speed over the base B C one measure of the friction can be obtained. The mean gradient from start to stop is another measure.

The following formula was used for calculating the friction from the speed observations :—

$$f = \frac{h - \frac{v^2}{2g}}{s}$$

where $2240f$ is the friction of the car reckoned in lb. per ton, h the fall in feet from the point where the car started to the middle point of the base B C, and s the distance from the starting-point to the middle point of B C.

$1/f$ is the gradient due to the friction ; that is, the greatest gradient on which the car would stand without moving, or if put in motion would run without acceleration.

The following table gives the values of the friction calculated from the observations :—

Gravity Trials. Speed Observations.

No. of run	*s*. Distance from starting-point to middle of base B C, in feet	*l*. Length of base B C for which time of passage was taken, feet	*t*. Time over base, sec.	$l/t = v$. Mean speed over base, foot per sec.	*h*. Fall from starting-point to middle of base B C, feet	$\frac{v^2}{2g}$	*f*. Friction of vehicle in lb. per ton	*i*. Gradient corresponding to friction	Mean
				Daimler Motor Company, London.					
2	400	200	10·0	20·00	16·77	6·28	58·9	1 in 38	1 in 45
4	300	200	11·8	16·94	10·25	4·46	43·2	1 in 52	
3	400	200	9·4	21·27	16·77	7·04	54·4	1 in 41	
				Lancashire Steam Motor Company, Leyland.					
5	384	168	21·2	7·93	16·77	0·98	92·0	1 in 24	1 in 25
7	396	192·5	22·0	8·75	16·77	1·19	88·0	1 in 25	
9	400	200	18·0	11·11	16·77	1·92	83·1	1 in 27	
8	400	200	11·4	17·54	16·77	4·79	67·0	1 in 33	
				Steam Carriage and Waggon Company, Chiswick.					
10	400	200	14·4	13·89	16·77	3·00	77·0	1 in 29	1 in 29
11	400	200	15·0	13·33	16·77	2·76	78·4	1 in 29	

NOTE.—In Run 3 with the Daimler car the engine but not the gearing was disconnected. In Run 8 with the Leyland car the engine was disconnected.

It will be seen that the Daimler car had the least friction, viz., $\frac{1}{45}$th of its weight, or 51 lb. per ton. The Thornycroft car had a friction of $\frac{1}{29}$th of its weight, or nearly 78 lb. per ton. The Leyland car had a friction of $\frac{1}{25}$th of its weight, or nearly 88 lb. per ton. With the engine disconnected the Daimler car had a friction amounting to $\frac{1}{41}$ of its weight, and the Leyland car had a friction amounting to $\frac{1}{33}$rd of its weight, or 67 lb. per ton.

From the difficulty of getting the speed quite accurately, and also to some extent because the method of calculation is approximate, probably these results are not quite so trustworthy as those obtained in the following manner, in which the friction is calculated from the distance from starting to stopping.

Friction calculated from distance of running from starting to stopping. Let s be the total distance the car ran, and h the fall of level in that distance. Then h/s is the gradient due to friction, and corresponds to i/f in the previous calculation.

A table of the results of the observations calculated in this way differed only slightly from the previous results.

X. *Experiments by Professor H. S. Hele-Shaw, F.R.S., for the Royal Lancashire Agricultural Society*, 1897.

Professor Hele-Shaw made a number of experiments for the above Society at their show held at Southport, 1897. Among other results he obtained the tractive force for agricultural waggons and carts, on turf and roads.

The following is a brief summary of the results obtained :—

—	Diameter of Wheels in inches		Width of Tyres in inches		Weight of Waggon or Cart in lbs.	Load in tons	Tractive Force per ton of Load on Turf	Tractive Force per ton of Load on Road
	Fore	Hind	Fore	Hind				
Agricultural Waggon.	39	42	4	4	2,142	3	235	148
,, ,,	39	42	4	4	1,895	3	277	125
,,	37	41	4	4	1,813	3	289	139
,,	36	40	4	4	1,752	3	227	170
Agricultural Cart .	65	—	3	—	1,281	1½	269	116
,, ,,	60	—	4¾	—	1,435	1½	260	147
,, ,,	59	—	4½	—	1,235	1½	332	111
,, ,,	59	—	4½	—	1,278	1½	240	109
,, ,,	58	—	4	—	1,330	1½	253	130
,, ,,	57	—	4½	—	1,379	1½	248	153
,, ,,	56	—	4	—	1,148	1½	235	108

XI. *Investigations of Ira O. Baker, M.Am.Soc.C.E.* (1902).

The resistance to traction of a vehicle upon the road consists of three independent elements: I. Axle friction; II. Rolling resistance; and III. Grade resistance. Nothing need here be said about grade resistance, since it is perfectly understood that it is equal to 20 lb. per ton for 1 per cent. of grade.

I. *Axle friction.*—It has nothing to do with the surface of the road. The coefficient of friction varies with the material of the journal and its bearings, and with the lubricant. It is nearly independent of the velocity, and according to the author's experiments seems to vary inversely as the pressure.

For light carriages when loaded the coefficient = 0·020[1] of the weight on axle.
For heavier ,, ,, ,, ,, = 0·015[1] ,, ,,
For American thimble skein waggon ,, = 0·012[1] ,, ,,

If there is a deficiency of lubricant, these figures are two to six times greater. General Morin's value for axle friction was 0·065; this difference is probably due to the better mechanical construction of the present day. The tractive force required to overcome the axle friction is about 3 to 3½ lb. per ton of the weight on the axle for ordinary waggons, and from 3½ to 4½ lb. for waggons with medium-sized wheels and axles.

II. *Rolling resistance.*—The resistance of a wheel to rolling is due to the yielding or indentation of the road, which causes the wheel to be continually climbing an inclination. The resistance is measured by a horizontal force necessary at the axle to lift it over the obstacle, or to roll it up the inclined surface. The rolling resistance varies with:—(*a*) The diameter of the wheel; (*b*) The width of the tyre; (*c*) The speed; (*d*) The presence or absence of springs on the vehicle; (*e*) The nature of the road surface.

(*a*) *The diameter of the wheel.*—The rolling resistance varies inversely as some function of the diameter of the wheel, since the larger the wheel the greater[2] the force required to pull it over the obstacle.

The results of the experiments are shown in Table I., data as follows:

The three sizes of wheels used: (44″ in front and 56″ hind wheels) = 50″ wheels.
,, ,, ,, (36″ in front and 40″ hind wheels) = 38″ wheels.
,, ,, ,, (24″ in front and 28″ hind wheels) = 26″ wheels.
The load being 1¾ ton of 2,000 lb. per ton and with tyres 6″ wide.

---

[1] The above figures assume good lubrication.

[2] Less.

Morin concluded that the resistance varies inversely as the first power of the diameter of the wheel.

Dupuit that it varies inversely as the square root.

Clark that it varies inversely as the cube root.

Baker that it varies very nearly inversely as the square root of the mean diameter.

(*b*) *Width of tyres.*—If the wheel cuts into the road, the traction is thereby increased; but for surfaces where there is little or no indentation the width of tyre has practically no effect upon the traction (see Tables II. and III.)

(*c*) *Effect of speed.*—The rolling resistance increases with the velocity owing to the effect of the shocks or concussions produced by the irregularities of the road surface. It requires from two to six or eight times as much force to start a vehicle as to keep it in motion at two to three miles an hour. The extra force required is due to:—(1) During the stop the vehicle has partly sunk into the road; (2) Axle friction is greater at starting than after motion has begun; (3) Energy is consumed in accelerating the load (see Table IV.)

(*d*) *Effect of springs.*—Springs decrease the traction by decreasing the concussions due to the irregularities of the ground, and are therefore more effective at high speeds than low, and on rough roads than on smooth.

(*e*) *Different road surfaces.*—The tractive force was obtained by a Baldwin dynagraph. The instrument consists of two long flat springs fastened together at their ends, and having their centres farther apart than their ends. One end of the apparatus is attached to the waggon, and the other to the team. The pull of the team causes the centres of the flat springs to approach each other. One spring supports a graduated disc, and the other is connected to an index arm which is pivoted at the centre of the graduated disc. From one end of this index arm the pull can be read directly from the graduation. There are two extra index arms, one to indicate the maximum power developed, and the other to indicate a rough average. The end of the index arm, opposite the graduated arc, records the amount of traction upon a strip of paper which is wound from one cylinder to another by clockwork (see Tables V. and VI.)

TABLE I.—*Effect of the Size of Wheels on Traction.*

Description of the Road Surface	Tractive force, lb. per ton		
	Mean Diameter of Front and Rear Wheels		
	50″	38″	26″
Macadam, slightly worn, clear fair condition . .	57	61	70
Gravel road, dry, sand 1″ deep, loose stones . .	84	90	110
„ „ up grade 2·2 per cent., ½″ wet sand, frozen below.	123	132	173
Earth road, dry and hard	69	75	79
„ „ ¼″ sticky mud, frozen hard below, rough	101	119	139
Timothy and bluegrass sod, dry, grass cut . . .	132	145	179
„ „ „ wet, spongy . . .	173	203	281
Cornfield: flat culture; across rows, dry . . .	178	201	265
Ploughed ground; not harrowed, dry, cloddy . .	252	303	374
Average value of the tractive power . .	130	148	186

TABLE II.—*Effect of the Width of Tyres (load 1 ton).*

Description of the Surface	Resistance to Traction lb. per ton Width of Tyres 1½″	6″
Broken stone road.—Hard, smooth, no dust, no loose stones, nearly level.	121	98
Gravel roads.—Hard and smooth, few loose stones, size of black walnuts.	182	134
„ „ Hard, no ruts, the large quantity of sand prevented packing.	239	157
„ „ New gravel, not compact, dry	330	260
„ „ Wet, loose sand, 1″ to 2½″ deep	246	254
Earth roads.— Loam, dry, loose dust, 2″ to 3″ deep . . .	90	106
„ „ „ „ hard, no dust, no ruts, nearly level .	149	109
„ „ „ stiff mud, drying on top, spongy below .	497	307
„ „ „ mud 2½″ deep, very sticky, firm below .	251	325
„ „ Clay, sloppy mud, 3″ to 4″ deep, hard below .	286	406
„ „ „ dry on top but spongy below, narrow tyres cut in 6″ to 8″.	472	422
„ „ „ dry on top but spongy below . . .	618	464
„ „ „ stiff, deep mud	825	551
Mowing land.—Timothy sod, dry, firm, smooth, narrow tyres cut in 1″.	317	229
„ „ Timothy sod, moist, narrow tyres cut in 3½″ .	421	305
„ „ Soft and spongy, grass and stubble 3″ high; narrow tyres cut in 6″.	569	327
Pasture land.—Bluegrass sod, dry, firm, smooth	218	156
„ „ „ „ soft, narrow tyres cut in 3″ . .	420	273
„ „ „ „ narrow tyres cut in 4″	578	436
Stubble land.—Corn stubble, no weeds, nearly dry enough to plough.	631	418
„ „ Corn stubble, some weeds and stalks, dry enough to plough.	423	362
„ „ Corn stubble in autumn, dry and firm . . .	401	256
Ploughed land.—Freshly ploughed, but not harrowed, surface rough.	510	283
„ „ Freshly ploughed, harrowed, smooth and compact	466	323

TABLE III.—*Effect of the Width of Tyres on Traction.*

Description of the Road Surface	Resistance to traction in lb. per ton of 2,000 lb.									
	44" and 46" Wheels				44" and 54"		42" and 46"		44" and 54"	
	Tyres				Tyres		Tyres		Tyres	
	1½"	4"	1½"	4"	1½"	4"	1½"	3"	1¾"	3"
Sod	—	—	—	—	—	—	283	239	189	228
Roads.—Earth hard .	—	108	—	—	—	—	152	152	114	114
,, ,, muddy	—	243	263	304	236	254	—	—	265	228
Sand.—Hard . .	199	163	171	164	141	168	—	—	—	—
,, Deep . .	371	351	—	—	—	—	—	—	—	—
Gravel . . .	—	—	98	117	83	80	—	—	66	76
Wood block : round .	51	49	61	70	35	46	—	54	28	38

TABLE IV.—*Effect of Speed on Tractive Force (after Morin).*

Description of the Road Surface		Resistance to traction in lb. per ton of 2,000 lb.					
		Stage Coach			Carriage		
		Walk	Trot	Fast Trot	Walk	Trot	Fast Trot
Broken stone road.	Good condition, dry, compact.	42	49	50	41	48	49
,,	Very firm, large stone visible.	59	75	81	58	73	81
,,	Little moist, or little dirty.	49	75	88	48	74	88
,,	Firm, little soft mud .	77	92	100	76	91	99
,,	Firm, ruts and much mud.	95	108	117	93	108	116
,,	Portions worn out, thick mud.	112	127	134	110	126	132
,,	Much worn, mud, ruts 3" deep.	146	161	169	145	160	168
,,	Very bad, rough, ruts 4" deep.	164	180	—	162	202	—
Stone block pavement.	Very smooth, narrow joints.	32	48	55	31	47	54
,,	Fair condition, dry .	35	52	61	34	51	67
,,	Moist, covered with dirt.	35	49	56	44	60	67

TABLE V.—*Traction of Different Vehicles on Various Level Roads, at 3 miles per hour, in lb. per ton of 2,000 lb. (after General Morin).*

Description of the Road Surface		No Springs						On Springs		
		Gun Carriage	Freight Cart		Artillery Waggons	Freight Waggons		Stage Coach	Carriage	Waggon
		Tyres 4·5″ Axle 3″ Diameter of Wheels 60″	Width of Tyres 4·5″ Diameter of Axle 2·5″ Diameter of Wheels 64″	80′	Tyre 3″ Axle 3″ Diameter of Wheels 45″ and 60″	Width of Tyres 4·5″ Diameter of Axle 2·5″ Diameter of Wheels 36″ and 60″	44″ and 78″	Tyres 4·5″ Axle 2·5″ Diameter of Wheels 36″ and 56″	Tyres 3″ Axle 2″ Diameter of Wheels 36″ and 56″	Tyres 2·5″ Axle 2″ Diameter of Wheels 50″ and 58″
Grass plat.	Very firm and dry . . .	72	—	—	82	—	—	—	—	—
,,	Moderately firm . . .	87	—	—	100	—	—	—	—	—
,,	A little moist	98	—	—	—	—	—	—	—	—
,,	Slightly wet	140	—	—	160	—	—	—	—	—
,,	Very wet, no water on surface .	—	—	—	260	—	—	—	—	—
Earth road.	Very good, nearly dry . .	57	55	44	66	74	63	77	76	64
,,	Covered with untrodden snow	109	105	84	125	140	120	146	—	123
Gravel road.	1¼″-1¾″ loose gravel on firm earth	147	143	114	169	190	163	198	198	168
,,	2″-2½″ ,, ,,	172	168	134	198	225	192	233	233	198
,,	4″-6″ ,, ,,	185	180	144	216	241	206	250	250	212
,,	4″-6″ ,, and fine sand	196	190	153	247	251	217	267	290	225
Broken stone road.	Good condition, dry and compact	32	30	24	37	40	34	42	41	35
	Very firm, large stones visible .	37	35	28	43	47	40	49	48	41
,,	Little moist or little dirty .	45	43	34	52	57	49	59	58	50
,,	Firm, little soft mud . . .	57	55	44	66	74	63	77	76	64
,,	Ruts and much mud . . .	70	68	54	81	90	78	95	93	79
,,	Portions worn out, thick mud .	83	80	64	96	107	92	112	110	94
,,	Much worn, ruts 3″, thick mud	109	105	84	126	140	120	146	145	123
,,	Very bad, ruts 4″, very rough .	121	118	94	140	157	134	164	168	139
Stone block pavement.	Very smooth, narrow joints .	25	23	18	29	31	26	32	31	26
	Fair condition, dry . . .	27	25	20	31	34	29	35	34	29
,,	Moist, covered with dirt . .	34	33	26	40	43	37	45	44	38
Plank road.	Thick oak, bridge floor . .	37	35	28	43	47	40	49	48	41

TABLE VI.—*Tractive Resistance of Level Pavements.*

Description of Pavement.	lb. per ton of 2,000 lb.
Asphalte.—Clean, smooth, no cracks, 52° F.	37
„ „ „ „ 84° F.	70
„ „ „ „ 42° F.	34
Brick.—3″ × 9″ bricks on concrete, corners rounded, sand filler, not worn.	17
„ 3″ × 9″ bricks on concrete, but newer and covered with ½″ dust.	31
„ 3″ × 9″ bricks on concrete, but cement filler; just completed	22
„ 2¼″ × 8″ brick on concrete, pitch filler; new . . .	24
„ 3″ × 8″ brick on gravel and cinders; sand filler, corners not round.	37
„ 2¼″ × 8″ brick on sand and old macadam, tar filler; new .	25
Granite block.—Smoothly dressed 3″ × 9″ blocks on concrete joints, ¼″ tar filler; not worn.	29
„ Smoothly dressed, on concrete, pitch filler; new .	30
„ Ordinary granite, 10 years' wear	36
Macadam.—Granite top, no dust, no mud	18
Plank road.—Oak plank, 3″ × 12″; nearly new	32
„ Same as above, after worn down ¼″ in many places; clean.	38
„ As above, covered with ¼″ fine loose dirt . . .	40
Steel wheelway.—8″. 11¼ lb. channel, on 2″ × 8″ pine, on macadam; covered with ⅛″ powdered stone.	40
„ „ Same as above, scraped clean with a shovel .	19
„ „ „ „ covered with ⅛″ fine dust . .	28
Wood block.—Rectangular blocks, 3″ × 12″, considerably worn .	36
„ „ Round cedar block, covered with ½″ silica pea gravel .	90
„ „ „ „ „ „ „ ¼″ crushed gravel .	50
„ „ „ „ „ clean, blocks slightly convex on top	53
„ „ Round cedar block, 2″ plank, 2″ sand, clean, not worn.	37
„ „ Same as above, clean, slightly worn	51
„ „ „ „ „ considerably worn . . .	54

3, 4 and 5 with wheels averaging 42½″ diameter, the remainder 47″.

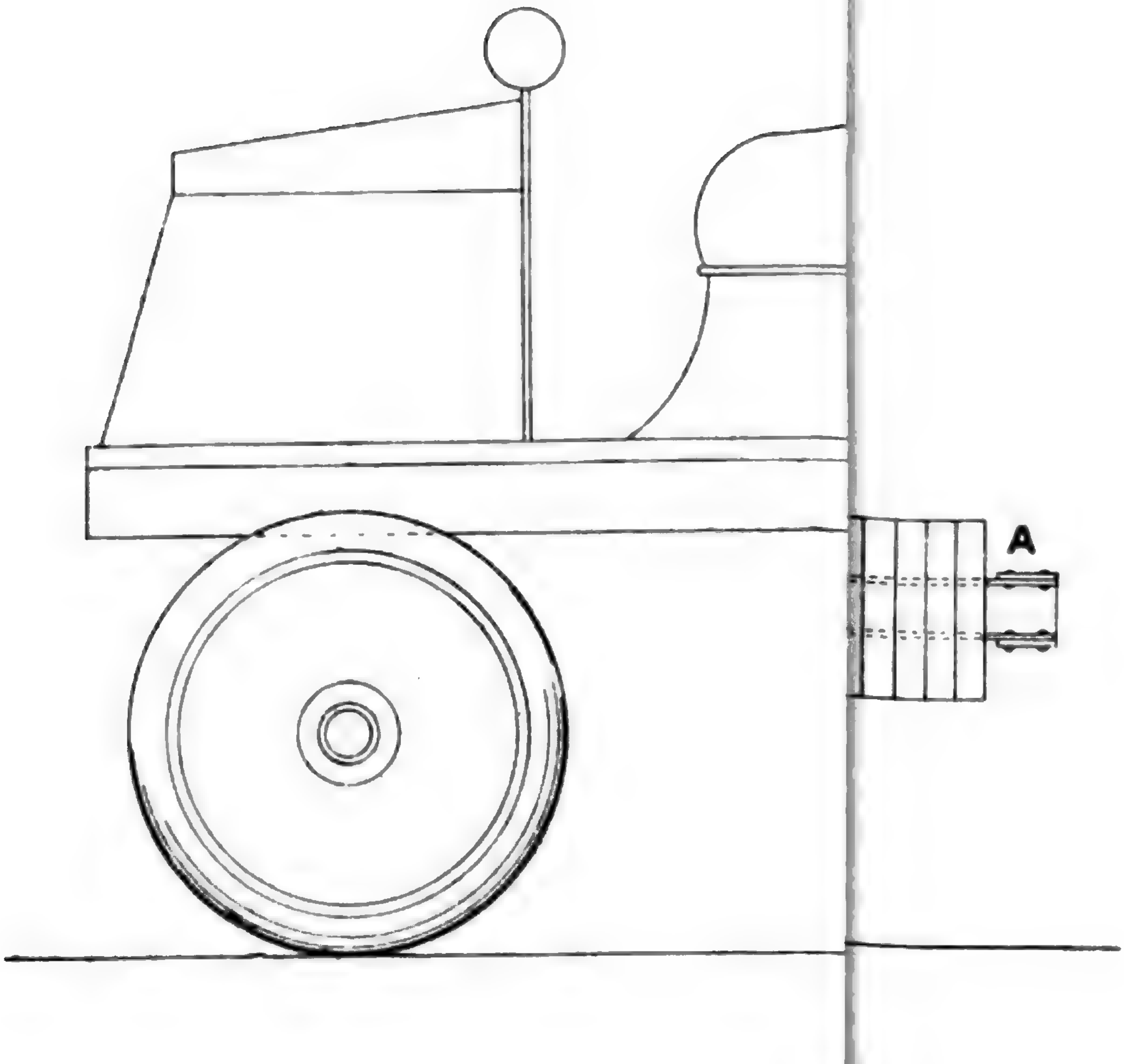
XII. *Summary of the Opinions of Various Writers on the Effects on Traction on the Level of the Independent Elements of Road Resistance.*

Tractive Force.

Authority	Date	Load	Diameter of Wheels	Width of Tyres	Nature of Tyres	Velocity	Springs	Deterioration of Roads
Edgeworth	1808	—	—	—		—	On rough roads increase of efficiency by one-third at 6·8 kilos per hour.	—
Corrége and Manès	1832	—	—	—		Increases with.	Diminishes on roads having irregular surfaces.	Proportional to load, width of tyre, and speed.
Coriolis	—	Directly proportional to the ¾th power.	Inversely as the cube root of the square.	Inversely as the square root.		—	—	—

Authority	Date	Load	Diameter of Wheels	Width of Tyres	Nature of Tyres	Velocity	Springs	Deterioration of Roads
Morin	1837–1842	Proportional.	Varies inversely as the first power.	Nearly independent for macadam and paved roads for sizes above ·08 m. to ·10 m. On compressible roads, such as loose earth, sand, gravel and new macadam traction decreases as width increases, the proportion depending on the condition of the road.	Iron tyres only were experimented with.	Independent on soft ground, such as soil, sand, &c., with or without springs. Increases for paved or macadam roads.	No effect on soft ground such as soil, sand, &c.	Inversely proportional to diameter of wheels.
Dupuit	—	Proportional.	Varies inversely as the square root.	Independent.		Independent on macadam and smooth roads; generally increases on paved roads.	Diminishes on paved roads. Very little influence on macadam roads.	—
Leahy	1847	Proportional.	Inversely proportional.	Independent.		Independent on soft surfaces. Varies as the second power on perfectly hard irregular roads.	Useless at very slow speeds.	—
Michelin	1896	—	—	—	Solid rubber tyre is better than iron in certain cases, especially if the road be sticky, very irregular, or covered with snow, but it is inferior to iron if road be hard and smooth. Pneumatics 50 per cent. better than iron.	—	—	—
Clark	—	—	Inversely as cube root.	- -	—	—	—	—
Baker	1902	—	Very nearly inversely as the square root of the mean diameter.	Almost independent.	—	Increases with.	Diminishes. More effective at high speeds than at low speeds.	—

British Association, 72nd Report, Belfast PLATE III.



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XIII. *Description and Drawings of the New Dynamometer made for the British Association Committee to carry on the Researches.*

The general arrangement of the new dynamometer made for the Committee to carry out the researches on road resistances is shown in Plate III. The apparatus comprises a castor frame, AA, in which can be mounted the wheel, B, to be experimented on, a system of levers, CC, for transmitting to a small plunger, E, the pull exerted on the wheel, and a recording pressure-gauge for registering the same, together with a recording tachometer.

Frame.—The castor frame is of wrought iron and is rectangular in shape. Its sides are of channel iron, 4 inches by 2 inches by ¼ inch, and are fastened together at the end by wrought-iron plates, ½ inch thick and 5 inches wide, bolted on at the top and bottom. The total length of the frame is 6 feet, and as the end plates have three sets of holes drilled in them, it can be arranged so that the sides are 10 inches, 14 inches, or 18 inches apart, to suit the various widths of wheels to be experimented upon.

Axle and springs.—The axle of the experimental wheel is mounted on springs, one under each side of the castor frame. The springs are 3 feet 2 inches centres, and each consists of six plates 2¼ inches by $\frac{3}{16}$ inch. When light wheels and loads are used these springs are reduced to a suitable strength by the removal of some of the plates. If desired the axle can be mounted on the frame without springs.

Loading.—The method of loading the frame is by bolting a series of 28-lb. cast-iron weights to the channel-iron sides. These weights are each 2 inches thick, so that when the scroll irons for the springs do not interfere, fifty-two or so can be affixed, thus giving a load of 13 cwt., besides the weight of the frame and wheel. This would correspond to a load of about 3¼ tons on a four-wheeled vehicle. This arrangement of loading enables the weight to be varied by steps of 56 lb., the weights always being arranged at equal distances on either side of the centre, so that the frame will never be out of balance.

Attachment of frame to car.—This frame is fixed to the levers which transmit the force to the water by a swivel joint, D, so that it is quite free to vibrate or bounce vertically as over rough ground; and it can also follow the car freely round any curve without in any way affecting the records, but it is held so that the experimental wheel is always vertical.

Levers.—The system of levers is so arranged that the frame can be raised or lowered to suit any diameter of wheel or any angle of draught without in any way altering the leverage of the mechanism. They may be described as follows.

A pair of similar bell-crank levers is mounted on a fulcrum which is capable of being raised or lowered in a vertical slot formed in a steel casting mounted firmly on the back of the car. The distances from this fulcrum to the ends of levers are respectively 14 inches and 28 inches, the longer arm being normally vertical, while the other is horizontal. To the shorter arm are attached two parallel vertical steel rods whose length is capable of adjustment. These rods serve to transmit the pull on the frame to one end of a small horizontal lever, the hydraulic plunger being at its other extremity. The fulcrum of this lever may be moved to either of four positions such that the pressure on the plunger is equal to one, two, four, or eight times the pull exerted on the castor frame. By having this arrangement it is possible to use the apparatus through a very wide range of experiments, say for tractive efforts of from 5 to 500 lb.

Plunger.—The plunger E, which is 2·6 inches diameter, presses upon a rubber diaphragm enclosing a space filled with water, and it is the pressure exerted on this water that is autographically recorded. Two pipes are connected to the water space, one for transmitting the pressure to the gauge G (Plate V.), the other being used for filling the system. An ordinary rubber bulb off a motor horn is filled with water and connected to this latter pipe, so that when the bulb is squeezed by the hand the water is forced through the system, and out of a small hole in the end of the Bourdon tube. By this means all the air is expelled, and when sure that such is the case the system is closed and the water retained.

Recording apparatus.—The recording apparatus was placed in the hands of Messrs. Schaffer and Budenburg, Ltd., Manchester, who have turned out a very good instrument. This apparatus is a combined recording pressure-gauge G and tachometer H (Plates IV. and V.) mounted on one base and recording on the same horizontal drum K, which carries a band of paper, LL, 8½ inches wide, the graph of tractive effort-space being at one side of the paper, while that of velocity-space is at the other side. This drum is driven off the tachometer spindle, and its motion therefore is in accordance with the motion of the car, a length of 10·3 feet of the paper corresponding to a mile of road. The makers have worked out a very neat parallel motion, so that the ordinates of both graphs are straight.

The instrument is mounted in a rain-proof glass case, supported on a pneumatic cushion, N (Plate III.), the drive to the drum and tachometer being through a flexible shaft. This arrangement has worked very well, fairly steady curves being obtained even over rough roads at high speeds. Stops are provided to prevent too great a movement of the levers, thus ensuring against undue shocks on the gauge.

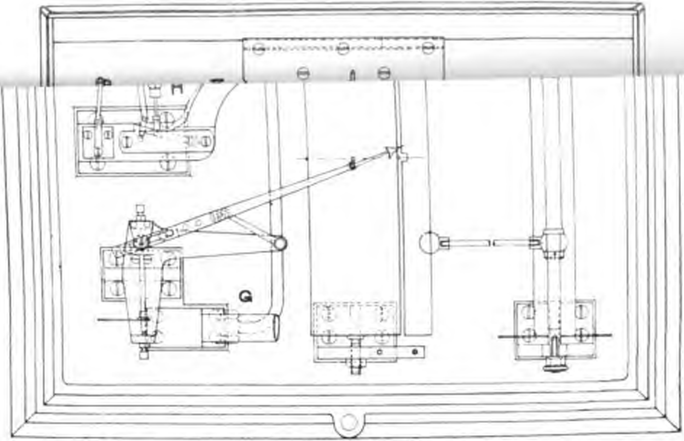
If found necessary an arrangement can be attached for marking seconds on the paper.

A revolution counter is provided for obtaining independently the revolutions of the experimental wheel: this will act as a check on the record.

XIV. *Nature and Scope of the Experiments by the Committee.*

Experiments will be conducted to determine the relation between the tractive effort and the following, viz., load, diameter of wheel, width and section of tyre, hardness of tyre (in the case of pneumatics), effect of springs, and velocity for every type of road under all circumstances, and any other relations that may be suggested during the progress of the work.

In performing an experiment a given type of wheel is mounted in the frame and a run made over a piece of road of the desired type. Since the two graphs are side by side the relation between tractive force and velocity can be seen at every point of the run, and from those portions of the graph where the velocity is constant and of the required value, a mean tractive effort can be obtained. After a number of experiments have been performed, curves can be plotted and empirical formulæ deduced for the various relations.



Plan of Pressure and Velocity Recording Instrument.

Illustrating the Report on the Resistance of Road Vehicles to Traction.

The relative value of the various roads are being compared by taking viagrams by means of a special instrument, the viagraph, kindly lent by the inventor, Mr. J. Brown, F.R.S., of Belfast.

XV. *The Work of the Committee presented at the Meeting.*

After a good deal of delay, due to various causes, the dynamometer was at length completed about August 20. It was then calibrated in the following manner. The car and dynamometer were placed on a smooth horizontal floor with a 40-inch lurry-wheel mounted in the frame. The car itself was prevented from moving backwards, and a given load was attached to a wire fixed to the wheel at the top and passing over the tyre, so that it hung vertically, thus tending to pull the frame away from the car. After a load was applied the apparatus was shaken to prevent it from sticking in any way, the paper meanwhile being uniformly moved until the pencil of the pressure-gauge had moved to its position of equilibrium. This was done with every reading. When the leverage of 8 to 1 was being calibrated, increments of 2 lb. were used in almost every case from 0 to a total of 82 lb. For the 4-to-1 leverage increments of 14 lb. were taken, after 14 lb. had been reached, the highest reading being 168 lb., the 2-to-1 leverage had increments of 14 lb., the highest being 280 lb., while the 1-to-1 leverage had increments of 28 lb. up to a total of 530 lb. Calibration curves were drawn for each leverage, and scales were drawn from these curves. Nine large wall-diagrams have been prepared for the meeting, the first being the calibration curve for the dynamometer when the 4-to-1 leverage was in use.

The tachometer was calibrated by driving it with an electric motor. The exact time of three revolutions of the drum was taken by means of a stop-watch for readings of 10, 15, 20, 25, and 30 miles per hour on the scale (three revolutions of the drum correspond to 315 revolutions of tachometer spindle). The mean diameter of the back wheels of the car was taken as 842 mm. when the car was normally loaded and tyres normally inflated; the diameter of pulley on back axle is 225 mm.; diameter of tachometer pulley 75 mm. Working out the speed from these data, the calibration curve shown on wall-diagram No. 2 was obtained, thus showing that the scale readings are reliable. It might be argued that if the driving wheels of the car slipped on the road, the tachometer is really reading higher than it ought to do; but as readings are only used for which the velocity is constant very little slip may be expected; and since it is not impossible for the driving belt of the tachometer to slip, thus giving too low a reading, it is not too much to assume that these errors will balance each other to some extent.

The method of operating the dynamometer and performing a trial is as follows:—The castor frame is pushed towards the car, so that the ram is as far out of the cylinder as possible; the bulb, having been previously filled with water, is squeezed by the hand, so that the water is forced through the cylinder, through the connecting tubing, and out through the opening in the end of the tube of the pressure-gauge. This method of filling ensures the removal of all air. When all the air has been removed the cocks at each end of the system are closed. The stops have now to be adjusted so that the maximum pressure of the water cannot exceed 100 lb. per square inch, or else the gauge might be destroyed. After the adjustments are satisfactory a run is made to some definite point over a given piece of road whose surface is of the desired type, a return run being made over the same road back to the starting-point. By taking the mean values for the double journey, out and return, the effect of inclines is eliminated. The load is then increased and the route traversed again, and so on. For the first few experiments for a given load the speed was given a succession of values ranging from 6 to 14 miles an hour, all in the outward run, just remaining constant at each speed for a sufficient distance to give a definite reading on the paper, and during the return journey the speeds were gone through in the reverse order, so that as near as possible the same piece of road was traversed at the same pace in each direction, this procedure being repeated for each load. This was not found very satisfactory on the whole, so that for the succeeding experiments a given space was covered both on the outward and return journeys at a definite speed. The same journey was then traversed under a higher constant speed, and so on, until sufficient readings had been obtained to give a curve. This process was gone through for each load. This method, although slower than that tried at first, was found to give much more satisfactory results. As the dynamometer has only been completed such a short time, the trials are as yet only preliminary; the general results, however, tend to confirm those of previous investigators. The diagrams to be shown at the meeting have not been reproduced here, it being thought unnecessary, as they will have to be all reproduced in the next report, by which time the striking results brought out by them, if duly confirmed, will by repeated experiment have been placed beyond question.

Experiments.

The first experiment was conducted near Sefton with an ordinary light lurry wheel, 40 inches diameter, having a 3-inch iron tyre, slightly rounded in section. This wheel was kindly lent by Messrs. T. Coleburn & Son, Cherry Lane, Walton, who have also promised to lend different sizes of wheels of a similar type for the experiments.

The wheel was mounted on a pair of springs, 3 feet 2 inches centres, each having six plates 2¼ inches by $\frac{5}{16}$ inch. Three different runs were made with loads of 3½, 5½, and 8½ cwt. respectively, with velocities ranging from 6 to 14 miles per hour. The results obtained, however, were not very satisfactory.

The second series of experiments were made with the same wheel and springs as were used in the first series, viz., light lurry wheel, 40 inches diameter, having 3-inch tyre slightly rounded in section, the springs each consisting of six plates 2¼ inches by $\frac{5}{16}$ inch. The route was a portion of Regent Road, Bootle, which runs parallel to the line of docks, and is quite level. It is paved with setts, 6 inches by 3 inches, with a 1-inch gap, and has a regular but fairly rough surface. Two runs were made with loads of 6 and 8½ cwt. respectively, at speeds of from 5 to 14 miles per hour.

A wall-diagram will be exhibited showing the results of the series of experiments. For both loads the tractive effort increased rapidly with the velocity, and at the same time was fairly proportional to the load. A diagram showed the results plotted as tractive effort per ton.

The third series of experiments were made with a pneumatic-tyred wheel 24 inches diameter, 2¾ inches tyre. The springs, 3 feet 2 inches centres, each consisted of two plates 2¼ inches by $\frac{5}{16}$ inch. This trial

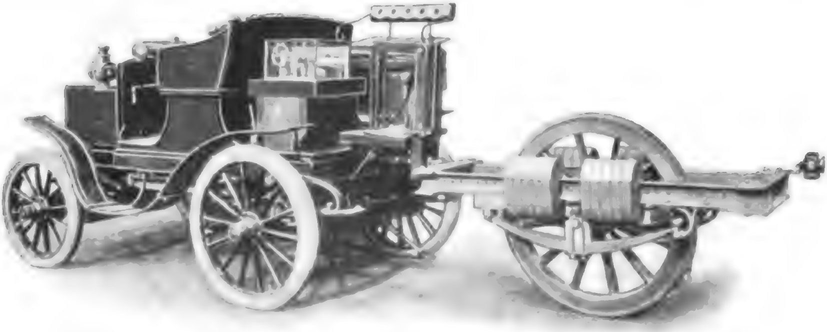


FIG. 1.—General view of Dynamometer, with 40-in. lurry wheel in frame.

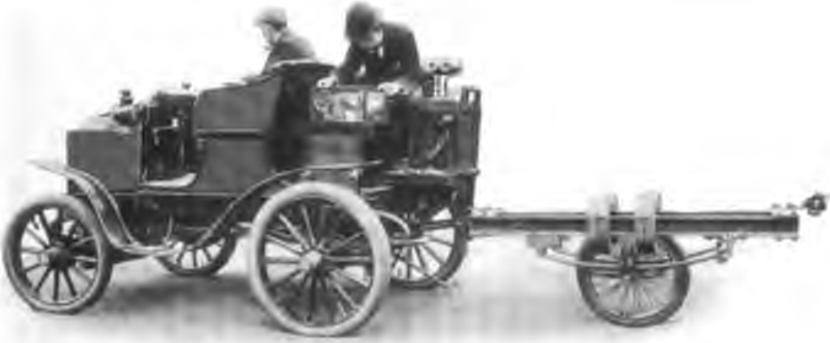


FIG. 2.—General view of Dynamometer, with observer in position. Pneumatic-tyre wheel in frame.

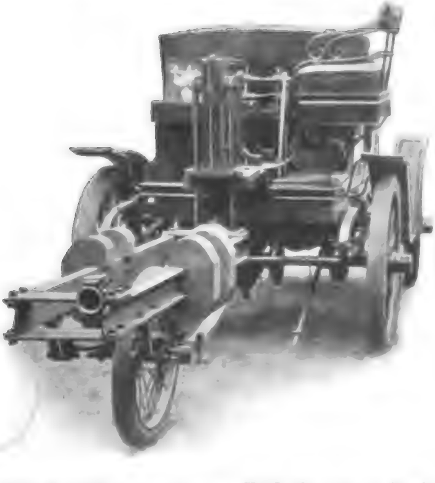


FIG. 3.—Dynamometer. End view from back.

Illustrating the Report on the Resistance of Road Vehicles to Traction.

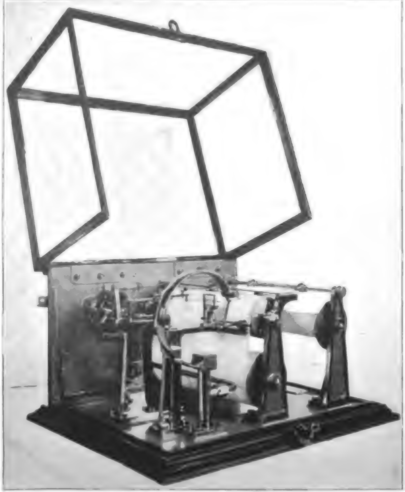


FIG. 1.—Recording Instrument.

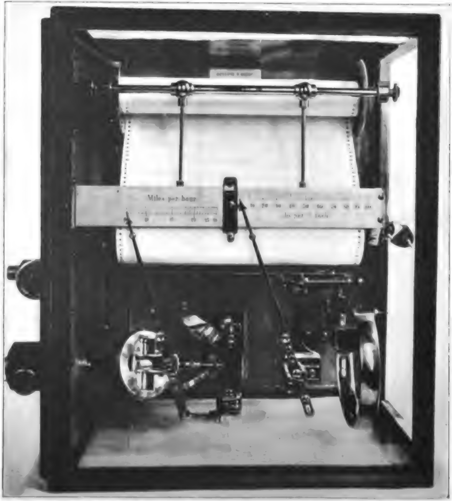


FIG. 2.—View looking down upon Recording Instrument.

Illustrating the Report on the Resistance of Road Vehicles to Traction.

was made on September 5 on a level stretch of macadam road passing through Ince Woods, near Sefton. The surface was in fairly good condition, slightly wet in places.

With these series of experiments a run was made with a given load at a constant speed to a spot about ½ mile from the starting-point. The return run was made at the same speed. With the same load a higher speed was then taken, and so on, so that for each load readings were taken at about 6½, 8, 10, and 14 miles per hour. This method of procedure was followed for each load carried. The leverage used was 4 to 1, and the loads were respectively 315, 427, 539, and 651 lb.

Wall-diagram No. 5 showed the tractive-effort-velocity curves for each load. It was noted that the tractive effort was directly proportional to the load, but increased very slightly with the velocity. This was what was observed by M. Michelin in his experiments.

Wall-diagram No. 6 showed a curve plotted between tractive effort and load for the above. It being a straight line showed that the tractive effort was directly proportional to the load.

Wall-diagram No. 7 gave the four curves of diagram No. 5 plotted as tractive effort per ton.

A specimen of the graph was reproduced on a large scale as a wall-diagram to show the nature of the curve obtained. In the experiments which have been made as yet, only level roads have been tried ; and it was not possible on a level road, dragging the wheels behind, to experiment satisfactorily with speeds of more than 15 miles per hour with the present car. For higher readings than this experiments will be conducted on an incline of such a gradient that a positive reading is recorded on the dynamometer, so that to find the pull on the wheel for the velocity it is only necessary to add to the registered pull the component of gravity parallel to the surface in question. By this means it will be possible to reach speeds up to 30 miles per hour.

Behaviour of Apparatus.

The behaviour of the apparatus is on the whole very satisfactory. The experimental wheel runs very steadily behind the car, even with heavy loads at high speeds. The lurry wheel, however, runs better on setts than on macadam, as it oscillates sideways somewhat when passing over the latter at a high speed. The pneumatic-tyred wheel runs exceedingly steady over all roads at all speeds.

The pneumatic cushion answers very well. It allows the instrument to swing gently from side to side in place of being subject to the violent vibration set up by the shaking of the car, due both to the engines and to rough roads.

The results just given were all it was possible to obtain during the short time before the meeting that the apparatus has been available, but it is hoped that during the ensuing year reliable and valuable results may be obtained, although, of course, to get a complete series of results under all conditions must necessarily involve an immense amount of time and labour, as with so many variable quantities the changes could be rung on them *ad infinitum.*

Plate VI. (figs. 1, 2, and 3) shows photographs of the dynamometer ready for use, Plate VII. (figs. 1 and 2) views of the recording instrument.

Small Screw Gauge.—Report of the Committee, consisting of Sir W. H. PREECE (*Chairman*), W. A. PRICE (*Secretary*), Lord KELVIN, Sir F. J. BRAMWELL, Sir H. TRUEMAN WOOD, Major-Gen. WEBBER, Col. WATKIN, Lieut.-Col. CROMPTON, A. STROH, A. LE NEVE FOSTER, C. J. HEWITT, G. K. B. ELPHINSTONE, E. RIGG, C. V. BOYS, J. MARSHALL GORHAM, O. P. CLEMENTS, W TAYLOR, Dr. R. T. GLAZEBROOK, *and* MARK BARR, *appointed to consider means by which Practical Effect can be given to the introduction of the Screw Gauge proposed by the Association in* 1884.

THE Committee have received during the past year further evidence on the subject of the small screw gauge.

Mr. Mark Barr has been elected a member of the Committee.

The principal institutions of the engineering profession, viz.—

The Institution of Civil Engineers ;
The Institution of Mechanical Engineers ;
The Iron and Steel Institute ;
The Institute of Naval Architects ; and
The Institution of Electrical Engineers—

have formed a strong and important committee to consider the whole question of standardisation of engineering materials, tools, and machinery. It is being favourably supported by the Government. The question of screws must naturally come before them. The Committee propose to submit evidence to that committee of the work they have done, and they ask for reappointment for the ensuing year, with a grant of 5*l.* to cover posting and clerical work.

Anthropometric Investigations among the Native Troops of the Egyptian Army.—Interim Report of the Committee, consisting of Professor A. MACALISTER (*Chairman*), Dr. C. S. MYERS (*Secretary*), Sir JOHN EVANS, *and* Professor D. J. CUNNINGHAM.

THE Committee have to report that owing to the pressure of other work since his return to England Dr. Myers has not yet been able to summarise the results of the anthropometric work in Egypt and in the Soudan upon which he was engaged last winter. In the present statement only a brief description has been given of the material which he has collected and of the means by which it was obtained. The expenses of the research were in part defrayed by the Government Grant Committee of the Royal Society and by the British Association for the Advancement of Science. The best thanks of the Committee are due to the Sirdar of the Egyptian Army, Sir F. R. Wingate, K.C.B., &c., and to many of his officers for their great interest and their unfailing assistance to Dr. Myers in his work.

The investigations were confined to the privates and non-commissioned officers of the Egyptian Army. By the kind permission of the Sirdar, Dr. Myers examined 1,005 men in the Egyptian battalion quartered at Cairo, and 189 men in the Soudanese battalions at Khartoum and Omdurman. The following measurements were taken :—

Height (1) sitting, (2) standing, (3) kneeling ; height above the ground of (4) ear-hole, (5) chin, (6) acromion, (7) elbow, (8) wrist, (9) trochanter, (10) knee, and (11) ankle ; maximum (12) breadth and (13) length of head ; (14) upper and (15) total length of face ; (16) bimalar, (17) bizygomatic, (18) biauricular, and (19) bigonial breadth ; (20) width of mouth ; (21) minimum frontal breadth ; (22) external biorbital, (23) external biocular, and (24) internal biocular breadth. Nasal (25) breadth and (26) length ; (27) orbito-nasal and (28) biauricular arcs ; (29) horizontal circumference of head ; length of radius from the ear-hole to the (30) vertex, (31) forehead, (32) nose-root, (33) upper incisors, (34) chin, and (35) occiput ; (36) biacromial and (37) bitrochanteric breadth. Circumference of chest during (38) expiration and (39) inspiration ; (40) maximum and (41) minimum circumference of calf ; (42) maximum and (43) minimum circumference of arm ; (44) span of arms. About sixteen of these measurements were made on each individual. In all more than seventeen thousand measurements were collected.

Dr. Myers took photographs of 176 Egyptian and 31 Soudanese soldiers bare to the waist ; two photographs, one full-face, the other profile, were taken of each individual. Care was taken that the heads should preserve a constant distance from the camera ; in this way he has obtained results which may be of use for composite portraiture.

The colour of the skin and eyes, the colour and texture of the hair, were always noted. He also made numerous observations on the relative degrees of development of the helix, antihelix, tragus, lobe, &c., of the Egyptian and Soudanese ear. He recorded the general shape of the face, and of the head when viewed from above, from behind, and from the side ; also of the lips, nostrils, nose, and eyes. He has made copies and a few photographs of the tattoo-marks on the arms and foreheads of the Egyptian soldiers and of the scarifications on the faces of the Soudanese. In each case he has carefully noted the village, district, and tribe to which the individual under examination and his parents belonged.

In Egypt Dr. Myers examined 27 men whose parents were born in the province of Qaliubia, 22 in that of Sharqia, 120 in that of Daqahlia, 138 in that of Gharbia, 118 in that of Menufia, 61 in that of Beheira, 56 in that of Giza, 41 in that of Fayum, 31 in that of Beni-Suef, 42 in that of Minia, 89 in that of Assiut, 103 in that of Girga, 60 in that of Qena, and 3 in that of Assuan. These included 44 Copts ; the remainder were Mahommedans. Eight others came from Alexandria. Seventy-seven were of mixed origin, having Soudanese, Bedawi, or Turkish blood, or being the offspring of parents who came from different provinces of Egypt.

In the Soudan he had the opportunity of measuring soldiers drawn from a very wide region of Africa, extending westwards as far as Bornu and Baia, and southwards to Uganda. The greater number belonged to Kordofan, to Dar-fur, Dar-nuba, or Dar-fertit, or to the Shilluk or Dinka tribes. Many had never known the names of their parents' tribes. Others came from the districts of Bagirmi, Dar-runga, Banda, Bongo, Burun, Berta, or belonged to the Niam-niam, Nuer, Hamegawi, Digawi tribes, &c. A few 'Arabs' of the Soudan and eastern desert were also measured.

It remains to be seen how far the photographic, descriptive, and anthropometric data thus amassed will prove of use for determining whether definite differences of type exist among the Egyptians from various regions of the Nile valley and among the tribes of the Soudan ; also whether the Coptic (pre-Mahommedan) people noticeably differ from the general Moslem population of Egypt. Before publishing the results of this inquiry the permission of the Sirdar has to be obtained. The material collected will supply the necessary data to permit of the preparation of a report on the physical efficiency of the Egyptian Army.

Pigmentation Survey of the School Children of Scotland.—Report of the Committee, consisting of Mr. E. W. BRABROOK (*Chairman*), Mr. J. GRAY (*Secretary*), Dr. A. C. HADDON, Professor A. MACALISTER, Professor D. J. CUNNINGHAM, Mr. J. F. TOCHER, Dr. W. H. R. RIVERS. (*Drawn up by the Secretary.*)

THE progress made with the organisation of this survey during the past year has not been great, chiefly because it was doubtful whether the funds required to pay the cost of collecting the statistics could be obtained. The Scottish Ethnographic Committee, with which this Committee is co-operating, have, however, quite recently obtained the necessary funds, and steps are being taken to secure the co-operation of the school teachers, whose assistance is indispensable in carrying out the survey. An application for co-operation has been made to the Secretary of the Educational Institute of Scotland, and a very favourable reply has been received. Applications will also be made to all the local committees of that Institute and, where necessary, to individual teachers.

Forms are being drafted, and when they have been revised and passed by the Committee they will be sent out to all schools, probably about the end of this year, the time of issue being as far as possible fixed to suit the convenience of the teachers.

For the purpose of this survey it is intended to follow, as far as possible, the natural subdivision of the country into river basins, as it is well known that watersheds, when they form mountain ranges, even of moderate size, act as racial barriers. If the ordinary subdivision into counties were adopted, we should have in many cases to include populations with quite different characteristics in the same subdivision, and valuable ethnic distinctions would be lost in taking an average. Each river basin is to be subdivided into districts containing about 3,000 school children, except in the case of towns having a larger number than this, which will be treated as single districts.

The Clyde basin, which is the most populous in Scotland, has already been subdivided in this manner into twenty-two districts. The Clyde basin contains about one-third of the total number of school children in Scotland. The subdivision of the rest of Scotland is being proceeded with, and will soon be completed.

Each district will be numbered, and the forms sent to schools in each district will be stamped with its number. When all the filled-up forms for a district have been returned, the average for each colour of hair and of eyes for that district will be calculated, and the averages thus obtained will be marked on maps in their proper locality and used as density points for drawing contour lines of pigmentation.

The Committee ask to be reappointed, and as a considerable amount of actuarial work is involved in working up the statistics after they have been collected, the Committee recommend that a small grant be made to cover the cost of this work, so that it may be possible to present a satisfactory report to the British Association.

Ethnological Survey of Canada.—Report of the Committee, consisting of Professor D. P. PENHALLOW (*Chairman*), Mr. C. HILL-TOUT (*Secretary*), Mr. E. W. BRABROOK, Dr. A. C. HADDON, Mr. E. S. HARTLAND, Professor E. B. TYLOR, Sir JOHN BOURINOT, Mr. B. SULTE, Mr. DAVID BOYLE, Mr. C. N. BELL, Professor JOHN MAVOR, Mr. C. F. HUNTER, Dr. W. F. GANONG, *and* Rev. JOHN CAMPBELL.

IN our last report attention was directed to the efforts being made to enlist the co-operation of the various provincial Governments in the work of this Committee with a view of putting it upon a more permanent basis. At the Toronto Meeting of the Royal Society of Canada, held on May 27, the Council, in submitting its report, made a lengthy reference to our work, and pointed to the great necessity of having it prosecuted with vigour while material is available. A joint committee from Sections 2 and 4 was appointed to take the matter into consideration, with the result that the Society unanimously adopted the following resolution:—

'Resolved, that Hon. J. W. Longley, Sir James Grant, Dr. T. J. W. Burgess, Rev. John Campbell, Dr. George Bryce, Mr. Wilfrid Campbell, and Professor D. P. Penhallow, Chairman, as Chairman of the British Association Committee on an Ethnological Survey, be appointed a standing Committee to co-operate with the British Association Committee on an Ethnological Survey, and that they be empowered to take such steps as may be necessary to secure from the various provincial Governments, as also from the Dominion Government, the adoption of legislation relative to the establishment of national and provincial museums of ethnology, and the organisation of a permanent Ethnological Survey of the entire Dominion.'

The Ontario Government has already taken the initiative in such work, and it is believed that the admirable beginnings already made by Mr. David Boyle in the Archæological Museum connected with the Department of Education may serve as an incentive to similar efforts in other provinces.

The plan now before the Committee of the Royal Society of Canada will be prosecuted with vigour. It is substantially the one which the British Association Committee has had under consideration for some time, but which they have not been able to carry into effect. It contemplates the formation of a strong central committee as a nucleus within the British Association Committee. This central committee will control all matters relating to the direction and organisation of research and the distribution of funds. In return for financial support it will secure to the several provinces such ethnological material as may specifically relate to each, reserving any duplicates for exchange and for deposit in the British Museum or such other suitable place as may be selected.

Mr. Hill-Tout has continued to carry on his investigations among the Salish of British Columbia under greater difficulties than usual during the past year. Two of the three tribes which he has at present under observation were quarantined on account of an outbreak of small-pox among them just at the season when it was most convenient for him to be examining them. This and the shortness of the funds with which he was provided to prosecute the work have proved most serious obstacles to the completion of his report appended, and which is to be taken as a 'report of progress' only. The work has been carried out on similar lines to those followed last year, and much labour and care have been given ungrudgingly to it. His studies have been directed in particular to the Nū'tsak, the Ma'çQui, and the Siciatl. Those last are a coast people differing in speech and in many of their old customs from the contiguous Salish bands. The study of their dialect promises to add to our knowledge of the Salish tongue, and to reveal many interesting grammatical features. Within their boundaries they have also peculiar archæological remains in the form of stone enclosures, an account and full description of which will be found in the report appended hereto. Their customs and folk-lore will also be found interesting in their bearing on the question of totemism. It is encouraging to report that the Government of British Columbia has recognised the value and importance of Mr. Hill-Tout's work, and has this year assisted him by a grant of $150 towards his field expenses.

The Archæological Reports for Ontario, by Mr. David Boyle, give an excellent indication of what is being accomplished by independent effort along the lines which this Committee is designed to encourage. From the Report for 1900–1901 it would appear that the museum contains upwards of twenty-two thousand specimens illustrative chiefly of American archæology and ethnology, and of these by far the greater number are from the Province of Ontario. The accessions during the year 1901 numbered 959, and Mr. Boyle observes that the large increase in correspondence seems to indicate a growing interest in archæological and ethnological studies.

The Report for 1900 contains the following contributions :—

1. Notes on Museum specimens. By Mr. D. Boyle.
2. The Flint-workers : A Forgotten People. By Very Rev. Wm. R. Harris.
3. Indian Village Sites in the Counties of Oxford and Waterloo. By J. M. Wintemberg.
4. Bibliography of the Archæology of Ontario. By Mr. A. F. Hunter (noticed in our previous report).

The Report for 1901 contains :—

1. Notes on Museum Specimens. By Mr. D. Boyle.
2. A Supposed Aboriginal Fish-weir near Drumbo. By W. J. Wintemberg.
3. Indian Occupation in Nissouri. By L. D. Brown.
4. Animal Remains on Indian Village Sites. By Dr. Wm. Brodie.
5. Wampum Records of the Ottawas. By A. F. Hunter.
6. Notes on Huron Villages in Medonte, Simcoe Co. By A. F. Hunter.
7. Notes on North Victoria Village Sites. By Lt. G. E. Laidlaw.
8. Notes on Canadian Pottery. By F. W. Waugh.
9. The Paganism of the Iroquois of Ontario. By D. Boyle.

The Committee ask to be continued, with a grant of 50*l*., and they also recommend the appointment of Rev. Father Monies, Rev. Father A. G. Morice, and Mr. J. L. Myres as additional members.

Ethnological Studies of the Mainland Halkōmē'lᴇm, a division of the Salish of British Columbia. *By* Chas. Hill-Tout.

The following notes are a summary of the writer's studies of the Lower Fraser Indians. They deal chiefly with the Tcil'ꞯē'uk and Kwa'ntlᴇn tribes. The Indians inhabiting the Lower Fraser district comprise in all some fourteen or fifteen separate tribes, an enumeration of which was given by Dr. F. Boas in his Report on the Physical Characteristics of the North-West Tribes.[1] They occupy the shores of the estuary, extending up the river as far as Spuzzum, which forms the dividing-line between them and the N'tlaka'pamuꞯ beyond. Collectively they are known to themselves as the *Halkōmē'lᴇn* or *Henkōmē'nᴇm* people. By this convenient term I shall speak of them hereafter. The name, according to my informants, signifies 'those who speak the same language.' This division of the Salish is not confined to the Mainland. An important branch of it is found on Vancouver Island, over against the estuary. The speech of both branches, although exhibiting interesting dialectical differences, is mutually intelligible. The Halkōmē'lᴇm tribes occupy a larger and more scattered territory than any other of the Salish divisions of British Columbia, the distance between the most eastern and the most western tribes being upwards of 200 miles. When it is remembered that the speech of the Salish tribes which border upon them on every side is so strange and different as to be quite unintelligible to the Halkōmē'lᴇm people, the practical homogeneity of their own speech, despite the fact of their widely scattered territories, has a significance we cannot afford to overlook. It assuredly reveals to us, as plainly as the unwritten past can be revealed, that they cannot have occupied their present territories for any considerable time. The intercourse between the different tribes, as far as can be gathered from themselves, was never very free or extended, the nature of the country forbidding this. Consequently we should find vastly greater divergence in the speech of the upper and lower, the Mainland and Island, tribes than is the case if they had been settled for any great length of time in their present quarters. While the Salish language as a whole, with its dozens of dialects and scores of sub-dialects, displays such capacity for dialectical variation as it does, we can hardly believe that the same tendency to change is absent from the Halkōmē'lᴇm speech. We may safely conclude, therefore, that the Halkōmē'lᴇm tribes are comparative late-comers in the territories they now occupy. All lines of available evidence tend to confirm this view.[2] Whether the Island or the Mainland tribes constitute the parent branch, or whether the Island or the Mainland was the earlier home of the division, cannot now be determined. This, and the kindred question of the original home of the whole undivided Salish stock, will be dealt with later, when our investigations have covered the whole field of inquiry.

The Tcil'ꞯē'uk.

Ethnography.

The Tcil'ꞯē'uk have greatly decreased in number during the past two generations, though they do not appear to have ever been a populous tribe, even in the old days. As at present constituted the tribe is subdivided into eight separate groups or village communities, which together number about fifty adult males. The names of these villages and their respective chiefs, as given to me by 'Captain' John, *sīā'm* of *Sūwā'le*, are as follows:—

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[1] Ninth Report Brit. Assoc., 1894.

[2] See the evidence on this head under 'Archæology' below.

Villages.	Chiefs.	Number of adult males.
1. SQaı	Mō'tes	9
2. SQaiā'lō	Klaça lᴇm	4
3. A'tsᴇlits	Swaiū's	2
4. Skaukē'l	Qätēkū'eta	9
5. Yukūkwēū's	Qätē'selta	7
6. Tcla'ktᴇ'l	—	3
7. C'lä'lkı	Wēū'sᴇluk	1
8. Sūwā'lō	Swā'lᴇs	12

In earlier days the tribe was less scattered than at present, and had its settlements on the upper reaches of the Chilliwack River, contiguous to Sūwā'lō, the former headquarters of the tribe. I obtained from 'Captain' John the names of these old settlements. They are:—

Sūwā'lē = 'melting away'; so called because the people here once died in great numbers.
Skwᴇā'lēts = 'coming in of the water.'
St'lᴇp = 'home country'; so called because here, on a level stretch of land lying between the forks of the river, the old long communal houses of the tribe were situated.
Çáltelitc, from çaçal = 'back'; so called because the settlement was on the edge or 'back' of a slough.
Qō-Qai'â = 'maggot-fly'; so called because of the number of maggot-flies found there in the summer.

These settlements constituted the original home of the Tcil'Qĕ'uk, according to the traditions of the tribe. They have no record of any other ancestral home. In their own words, they 'have always dwelt there, looking on the same sky and the same mountains.' According to one of their myths, they dwelt here before the Chilliwack River sprang from the mountains. This river rises in a mountain lake known locally as 'Cultus' Lake, but called by the Indians themselves *Swī'eltca*; and its formation is said to have come about in the following manner. In the olden days there lived a youth who frequented this lake. Its shores were his training-ground. One day he came to the village and said he had learned in a dream (*úlīa*) how to make water run. The people laughed and jeered at him. Said he to them: 'To show you that I can do as I say I will make the water of the lake run by the village before the sun sets.' With that he started for the lake. A little later he appeared in the village again. 'Look out now,' he cried; 'the water will soon be here.' Presently a small stream of water was seen descending the slope. In a short time this increased to a rushing torrent, which, as there was no bed for it to run in, divided and ran in several directions, cutting out in its course the different channels or arms through which the water now flows before uniting in the one stream. It is quite possible this myth or tradition has some foundation in fact. The waters of the river are clearly the overflow of the lake. This overflow may have formerly had some other outlet, which for some reason or other failed to do its work, and a new outlet became necessary. While none of the Tcil'Qē'uk Indians entertain any doubt about the truth of this tradition, the younger and more intelligent of them believe that the youth of the story in his wanderings round the lake discovered some weak spot in its margin overlooking the slope occupied by the tribe, which required but a little assistance from him to become an outlet for the lake's overflow. They do not believe any longer in the 'magic' part of it. They are, indeed, now generally very sceptical of the marvellous feats and wonder-working powers of their old-time shamans, as recorded in the tribal myths and traditions. Thus we see the disintegrating forces introduced by our advent at work here, as in other sides of their life and character.

Sociology.

In their social organisation and customs the Tcil'Qē'uk differ in some interesting respects from the neighbouring Halkōmē'lEm tribes. This may be possibly due to the fact that the Tcil'Qē'uk are not true members of the Halkōmē'lEm division, though they now speak its tongue. They have a tradition among them that up to a century ago they spoke a different language. What this was even their old men could not remember. 'Captain' John gave me a few words which he said belonged to the old language. These are all true Salish terms, though non-Halkōmē'lEm. He also told me that an old man of their tribe lived among the Nootsak Indians, to the south of the International Boundary Line, who knew the old tongue. I paid a special visit to this settlement to see this old man, but failed to find him. I fear he is dead, as I could hear nothing of him. I learnt, however, that the Nootsak speech is closely allied to the Sk·qō'mic. The tribe is much broken down. It is now formed of members of several originally different tribes, only about a half-dozen true male Nootsak Indians being alive.

The Tcil'Qē'uk were more communistic in their mode of life than any tribe I have treated of heretofore. The people were divided into the usual threefold division of chiefs, notables, and base folk. The chieftaincy or headship of the tribe was practically hereditary ; though the people could depose their chief and elect another in his place if they were dissatisfied with his supervision of the tribe, or his conduct was such as to make him a bad director. I say *director*, rather than *ruler*, because the sīä'ms of the Salish were rarely, if ever, rulers in the ordinary sense of the word. They were rather overseers or fathers of the tribe, the sīä'm combining in himself the character and functions of a common father and a high-priest ; the office, indeed, being more sacerdotal than imperial. He it was who always led and directed the prayers of the community and conducted all their religious observances. To this day he leads them in their responses and conducts the service in their churches when their white minister or instructor is absent. Apparently the deposition of a chief was an extremely rare occurrence. This may possibly have been because the occupants of the office fully realised its dignity and its privileges, and had no desire to forfeit them ; but I am disposed to think it was more because they were usually genuinely impressed with the responsibility and duties of their position, and strove earnestly to fulfil them. At any rate, we hear very rarely of a bad or neglectful chief. The Tcil'Qē'uk traditions record but one such. A deposed chief would be succeeded by his son, or brother, or cousin ; so that the chieftaincy would rarely pass out of the family or caste of the chief. I inquired among the Tcil'Qē'uk what conduct on the part of a chief would bring about his deposition ; and was told that selfishness, or meanness, or neglect of the material welfare of the tribe would assuredly do so. I further inquired what course would be taken to depose him. They replied : The elders and chief men of the tribe would meet together and discuss the matter, and then the chief would be told that he was no longer sīă'm ; that his son, or his brother, or his cousin had been appointed in his place. The deposed chief would quietly acquiesce in the decision and the new chief would take his place ; and that would be the end of the matter. From this it is clear that although the office of sīă'm was practically hereditary, and generally descended from father to son, the chief held his position really on sufferance and with the common consent of the elders and nobles of the tribe. Apparently, among those Salish tribes which are subdivided into village communities there is always one chief of more importance than the rest. He is lord-paramount. It was so among the N'tlaka'pamuQ, the Kwa'ntlEn, the Sk·Qō'mic and the Tcil'Qē'uk. Among the latter he is called *Yūw'el Sīă'm*, which signifies 'the first-going chief.'

The prime duty of a Tcil'Qē'uk sīă'm was the care and order of the village or community. His chief thought was given to that, and he was deemed responsible for the common welfare and comfort of the tribe. He directed all undertakings in the common interest, and appointed the times for salmon-fishing, root-digging, and berry-picking. A popular chief was one who was generous, liberal, and kind-hearted, and looked well after the material comforts of the tribe. Rarely, if ever, did the sīă'm act in a military capacity. The *sta'miq*, or war-chief, was generally chosen from among the fighting-men of the tribe on account of his superior prowess or skill in warfare. There was no regular warrior class. Such members of the tribe only as were fond of fighting ever went out to battle, except in such cases as when their settlements or homes were attacked. Then all the men, and sometimes the women too, took part. But this was a rare occurrence. Their traditions speak of quarrels and contests with their neighbours, the Pila'tlq. These arose generally on account of one tribe overrunning the hunting-grounds of the other. Apparently the Tcil'Qē'uk were mostly to blame in this respect, often overstepping the boundaries between them and the Pila'tlq and hunting in the latter's territories. Sometimes a body of warriors would descend the Fraser, harry some of the lower settlements, and bring back a number of captives. These they would sell as slaves to the more timid or less adventurous of the tribe, and thus enrich themselves. The sīă'm would usually discountenance these forays ; but, as in every other tribe, there were also among the Tcil'Qē'uk some restless, venturesome spirits, and these would from time to time persuade others less warlike than themselves to join them, by tempting them with visions and promises of the rich spoils they would secure and bring home. Sometimes these war-parties were never heard of again, being ambushed and slain by the way.

I could learn little concerning secret societies or brotherhoods, though some such apparently formerly existed among them, the brotherhood of the *Sqoi'aqī* being the most noted. There were also, seemingly, fraternities which possessed peculiar dances ; but the whole subject is very obscure and its particulars difficult to gather among the Tcil'Qē'uk. In common with the other Salish tribes the Tcil'Qē'uk indulged in religious and social dances. They observed, too, the Feasts of First-fruits, which were conducted much as described by me in my notes on the N'tlaka'pamuQ in the Third Report of the Committee. These religious feasts seem to have been observed by all the Halkōmē'lEm tribes, as I find them among the upper and the lower tribes of the river.

The 'potlatch,' Mortuary, Naming, and other feasts were held in esteem by the Tcil'ꞯē'uk as by other of the Salish tribes, though all have been reluctantly given up as a general thing for some years past. Occasionally someone with a large house will be induced to give a dance, I was informed. This will be conducted partly on native lines and partly on the lines of the white man's dance; but all such gatherings are discountenanced by the Indian authorities and by the missionaries, and occur now but rarely.

The lines between the three social divisions of the Tcil'ꞯē'uk were less rigid than those between some of the coast tribes; at least, that is, between the notabilities and the common people. The chief's caste was a class apart. Only those connected by consanguineal ties could belong to this caste, the head of which was always the *yūw'el sīä'm*, who always bore the personal name or title of *swā'lᴇs* in addition to his other individual names; and his daughters were always called *swā'lᴇsä'nt*. I was unable to learn the signification of these terms, other than that 'swā'lᴇs' signified 'getting rich.' A noble or headman among the Tcil'ꞯē'uk was such by his wealth and intelligence and by the consent of his fellow-tribesmen. Any man, other than a slave, could win such a position for himself by the acquisition of wealth and by a generous and discreet distribution of the same. The common people, other than the slaves, were such because they were lazy, thriftless, unambitious, or incapable of rising in the social scale. As I observed at the outset, the Tcil'ꞯē'uk were more communistic than their neighbours; they held their possessions more in common. Thus, for example, they eat together as one family. The chief would call upon a certain individual each day to provide the meals for all the others, everyone, more or less, thus taking it in turn to discharge this social duty. The sick and old he would make the charge of those who were best able to take care of them. Thus all were provided for and none left in want. It must not be supposed, however, that all fared alike. Under such a rule there would be no incentive for any individual to lay in a good store of choice food, and the lazy and thriftless would reap the benefits of the toil and foresight of the industrious and careful. In each family the food-stores were always divided into three portions, and packed away separately on the shelves over the beds. At the back, where it was most protected from injury, dust, and smoke, was placed the choicest portion. This was intended for the sīä'm, who was entitled by his office to the best of everything. In the middle was placed the second best portion. This was for the owner and his friends, and others of his social rank. On the outside was stored away all the inferior food. This was for the common folk. Thus, by this division of their supplies, though their meals were communistic, there was given no encouragement to thriftlessness or indolence. This singular mixture of communism and privilege is an extremely interesting feature of the social life of the Tcil'ꞯē'uk. It seems, moreover, peculiar to them, as I have not found it elsewhere.

The tribe was originally endogamous; but later, closer contact with the neighbouring tribes made a strict observance of this rule impolitic, and led to the taking of wives from other communities. Polygamy was common among the Tcil'ꞯē'uk, a man having sometimes as many as ten wives. The number of a man's wives was ordered, as a rule, partly by his inclinations and partly by his ability to support them. Like most of the other tribes, they kept slaves, the wealthy possessing several of both sexes. These were generally captives taken in warfare or in some foray on some distant settlement.

Dwellings.

The permanent habitation of the Tcil'Qē'uk was, as I have said, the communal 'long-house.' The adoption of this style of dwelling, I learnt, was primarily for purposes of mutual protection and defence in cases of attack. It can readily be seen that such houses would be imperatively needful where the community was small, the number of males limited, and the tribe surrounded by hostile and predatory bands. Later, when this need was no longer felt, custom and a recognition of the social advantages of such a structure would operate to perpetuate this mode of building. I think there can be but little doubt that these dwellings, first erected for mutual safety and protection, have profoundly affected the social life and customs of the Indians using them. The communism of the Halkōmē'lEm and coast Salish tribes doubtless grew out of it; likewise their character dances, which are invariably performed during the winter days and evenings in these long common houses.

The long-house of the Tcil'Qē'uk was of the half-gable or single slope pattern, the front or higher side rising to 25 or 30 feet. The interior was equally divided between the different families of the tribe. Each family was entitled to a space 8 *talçs*[1] square. When the tribe was populous these houses would extend in an unbroken line for several hundred feet. The chief always occupied the centre. In this custom we have plain evidence of the truth of the statement made to me by the Indians, that they adopted this style of house primarily for protective purposes. The chief—the father and head of the tribe—whose loss would be most severely felt, is always lodged in the securest portion of the structure. On either side of him dwell his brothers, the elder ones coming first. After them come the lesser chiefs and notables, and beyond these again the common folk. There were commonly but two doors to these dwellings—one at each end. In the interior, the spaces allotted to family use were separated by hanging mats or screens of grass or reeds. On festive occasions these were taken down and the divisions thrown into one. The beds were formed by reed mats laid one upon another, the head-rests or pillows being rolls of the same. The coverings of the meaner class were of the same material; the wealthier supplemented these by dressed skins and blankets made from the wool of the mountain goat.

The 'keekwilee,' or underground winter-house, was also occasionally used by some of the Tcil'Qē'uk, and known to them by the term *skEm'EL*. *Lä'lEm* is the name by which the long-house was known; which, to judge by the *lām* of the Sk·qō'mic and other tribes, is the collective form of the term.

The household utensils of the Tcil'Qē'uk did not differ, except in size, from those used by their congeners elsewhere. These consisted of various forms of basketry, always made, as among the N'tlaka'pamuQ, from the split roots of young cedar-trees; wooden bowls, dishes, platters, and spoons. As their meals were of the communistic order, large receptacles were a necessity. Consequently we find these utensils habitually formed on a larger scale among the Tcil'Qē'uk than among the other tribes. They had enormous cedar troughs, 10 or more feet long and 2 or 3 feet wide, called *skwe'lstEl*; big maple dishes, called *kamō'molp lā'tsel*. Besides these were the ordinary *hĕk·lā'tsel*, or big platter; and the *mĕ'mel lā'tsel*, or small platter; the *qsī'EQEl'ç*, or wooden dipper or spoon, and the *qā'lō*, or horn-spoon.

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[1] A *talç* was the length of the interval or space between the outstretched arms of a man, measured across his chest from the tip of the middle finger on one hand to the corresponding point on the other.

Dress.

The dress of the Tcil'Qē'uk was similar to that of the contiguous Salish tribes described by me in former reports.

Shamanism.

Shamanism was prevalent among the Tcil'Qē'uk, and exercised a pervasive and paramount influence in their lives. The shamans were of three classes: the *sQElā'm*, or doctor, the term signifying 'to heal or make well'; the *o'līa*, or soothsayer, from *u'līa*, 'to dream'; and the *yeu'wa*, or witch, or sorcerer, from *yeu'wa*, 'to bewitch or enchant.' The last was of either sex; the others were invariably men. The office of the *sQElā'm*, despite his title of 'healer,' was not to attend to or cure wounds or such bodily injuries; that was one of the functions of the *o'līa*. There is great significance in this fact. An external wound or injury was a matter of comparatively simple import; there was nothing mysterious about it. It was the natural result of a known and comprehended cause. The functions of the *sQElā'm* were rather to restore health and vigour to the body when prostrate or suffering from some inward sickness or malady, as when under the supposed influence of some spell or enchantment. He was pre-eminently the 'pathologist' of the tribe. Pathological conditions among the Tcil'Qē'uk, as among other primitive peoples, were regarded as the result of maleficent and mysterious agencies, which could only be controlled or counteracted by incantations and rites performed by one versed in the 'mysteries,' as a SQElā'm. He alone had power to restore a lost soul or spirit, which, according to their belief, might leave the body, thereby causing sickness and fainting, and, if not restored in time, death; or drive out a disease caused by a magic spell or by witchcraft. To effect the former he would go apart by himself, crouch down, and cover his head and shoulders with a mat, and permit himself to pass into a trance state, when his soul, it is said, would leave his body and go in search of that of the patient. All the conceptions of the after-life of the Indians are derived from the descriptions given by the SQElā'm of these visits to the spirit-world. They are, consequently, rarely uniform or consistent. To effect the latter he beats a stick or board, and sings and dances round the patient. To acquire these powers he usually underwent a long and secluded training in some lonely spot in the forest or on the margin of some lake. This training consisted in prolonged fasts, trances, body washings and exercises, accompanied by invocations of the Mysteries. His 'medicine,' or 'power,' it is believed, was bestowed upon him by his guiding spirit or spirits, who appear to him and instruct him in dreams and visions. Another of his functions was to conduct the mortuary sacrifices. He is, *par excellence*, the 'Master of the Mysteries.'

Not only the shamans, but every other Indian, had one or more guiding or protecting 'spirits.' Their belief in these and their general belief in the 'mysteries' are based upon their philosophic conceptions, if such they can be called, of existence and the universe. In common with other primitive races, they people their environment with sentient beings and agencies of beneficent and maleficent character, mostly of the latter. Out of this conception spring their belief in, and their seeking by special means, personal guiding and protecting 'spirits,' or 'potencies'; which are akin to, but not identical with, the 'Manatous' of the plain Indians. Nature to them is full of 'mysteries'; and their perception of its laws is to endow every object and agency in their environment with conscious power and being. Surrounded thus by Potencies and Mysteries, capricious in action and generally malevolent in character, liable at any moment to be made their victims or prey, there was a vital need of a protecting 'influence' or 'spirit' in their lives. This 'guide,' 'protector,' 'influence,' 'power,' 'charm'—for it partakes of the character of all these—the Tcil'Qē'uk call by the name of *su'līa* or *so'līa*. This is the abstract or nominal form of the verb *u'līa*, 'to dream.' It is thus called because these 'potencies' come to and communicate with them in dreams or visions. A person's *su'līa* might be apparently anything—bird, beast, fish, object, or element. There was apparently no limitation, provided only that it came to him in a dream or vision. This is a fact of special significance, clearly showing that every object in Nature, animate or inanimate, possessed for them active and sentient powers and qualities. This fact is the more striking when it is remembered that parts of animals or objects, or even of human beings, might become a person's su'līa. Such su'līa, however, were rare among them. But their presence at all is of particular interest to us in our studies of the social organisation of the Indians of this region, as they seem to show us the steps by which the peculiar totemism of the northern tribes is reached. Such tribes as the Tcil'Qē'uk and others, who make su'līa of a tooth, a bone, a shell, a basket, or other utensil, a piece of hair or wood or stone, and similar objects, have clearly not yet passed beyond the stage of fetishism. Indeed, the Salish su'līa are throughout only higher forms of fetishism, in that they are always *individual* objects, no matter what those objects may be. Yet the su'līa of the Tcil'Qē'uk and other Salish tribes is not the fetish or talisman of the African savage; it partakes also of the character of the totem. It is, indeed, I am led to believe, the connecting-link between pure fetishism and totemism as it is found among our northern Indians. That the personal totem as we find it in this region has been evolved from fetishism I think the su'līa of the tribes under consideration make clear; and that the peculiar clan totem of our northern tribes is the further evolution and natural extension of the personal totem becomes equally clear under the study of the origin and spread of personal and family crests and emblems; these standing in the same relation to the clan totem as the fetish does to the personal totem. These crests and emblems, formerly so highly esteemed and jealously guarded by those entitled to them, which entered so largely and affected so profoundly the social life and organisation of our coast Indians, are seen to have originated in two different ways. One springs from pictographic or plastic representation of the su'līa, as among the interior Salish and the northern Alaskan tribes;[1] the other is an emblematic record of some event or adventure, more or less mythical, in the life of the owner or his ancestors, the nature of which is well exemplified in the story of the origin of the *sqōi'aqi* crest or totem given below. There can be little doubt, I think, that these latter gave rise to the secret societies and fraternal organisations of the Kwakiutl and northern Salish tribes; while the totems of the Haida, Tlingit, and Tsimshean sprang from the former. This I think becomes clear from a study of the social organisation of the various Salish tribes.

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[1] See 'The Eskimo about Bering Strait,' by Edward W. Nelson. Part I. of the *Eighteenth Annual Report of the Bureau of American Ethnology*.

Among the N'tlaka'pamuQ of the interior, whose social organisation is of the loosest and simplest kind, the crest, as such, was unknown. Pictographic, and even plastic, representations of their su'līa were by no means rare. The former were quite commonly found on personal belongings, such as utensils, weapons, clothes, &c., but they never appear to have assumed the character of the crest; they are merely decorative. When we descend the river and reach the Halkōmē'lEm tribes, the personal and family crest and fraternal emblems begin to appear. A carved or painted representation of an individual's su'līa is found on the posts of his house and on his family corpse-box, as well as upon other of his personal belongings. It has now become identified with the owner, and the owner with it. It is the mark or crest by which he and his are distinguished from others of the tribe. I have already observed that the adoption of the communal dwellings must have deeply affected the social life of those who inhabited them; and here, I think, we may see an instance of this. In communistic societies the individual is more or less lost sight of in the common family or brotherhood; but this is contrary to the spirit of the Indian character. Under the communistic organisation of the Tcil'Qē'uk it became necessary, then, to adopt some artificial means by which the personal and family units might retain their individuality in the tribal economy; and as pictorial representation of a person's su'līa was commonly employed to decorate his belongings, this, as a personal and family mark, may well have been adopted to supply the means. At any rate, however we may regard the association and identification of the individual with the representation of his su'līa to have come about, we see that among the Halkōmē'lEm tribes the idea of a personal distinguishing crest has been evolved from the earlier and simpler pictographic emblem of the su'līa. From the personal and family crest is but a step to the clan crest or totem; for the totems of our northern tribes are little more than symbols of unity, binding together by common possession the members of a gens or clan. The clan is but a collection of families; and when from any cause or purpose an association of families or gentes took place, it remained only for the strongest and most influential of these to absorb or adopt the rest, according to Indian custom, to give rise to the clan crest or totem. That this was done, and that amalgamation of groups of families or communities took place among the northern tribes, we may clearly gather from the abandonment of so many of their former village sites, as well as from their own traditions. Within these clans every gens had its own totem or totems or personal crests; and that these are, among the northern tribes, commonly animals does not in the least militate against the view of their origin here taken. It is but a higher, more advanced form of the su'liaism of the interior Salish and the Eskimo tribes to the north of them, among whom the animal su'līa is also commonly, though not exclusively, found, and is quite in accordance with the natural evolution of primitive philosophy. On both sides they are surrounded by tribes in the stages of fetishism or su'liaism, some of which have risen to the concept of the personal or family crest or totem; and when we know more of the *groundwork* of the beliefs of the Haida, Tlingit, and Tsimshean, as evidenced in their totemic systems, we shall, I am convinced, find that it does not differ in any essential feature from the fetishism and su'liaism of the neighbouring and, in these respects, more primitive tribes.[1]

Next in rank to the SQElā'm came the *O'līa.* One of his duties was, as I have intimated, to dress and cure wounds and other external injuries. His chief function, however, was to interpret dreams and visions, as his name indicates. He was specially skilled in the reading of omens and portents. Other of his functions were to take charge of the bodies of the dead and prepare them for burial, and protect the people from the evil influence of the *pālakōĕ'tsa*, or ghosts of the dead. Only an O'līa might venture to handle or have any dealings with a corpse or its *pālakōĕ'tsa*. He was able to see and hold communion with the latter, who, it was supposed, nightly haunted the burial-grounds. The people were consequently warned to keep away from such places, especially after recent burials. The O'līa figured also in the puberty and other social customs of the tribe. Last in rank came the *yeu'wa*, the witches or wizards. These dealt in *seu'wa*, or witchcraft. I have described in my notes on the neighbouring Pila'tlq, given below, how this was usually effected, so that it will be unnecessary to repeat it here.

Mortuary Customs.

The burial customs of the Tcil'QĒ'uk differ in detail from those already described. I was able to gather the following concerning them. As soon as the breath has left the body one or more o'līa immediately carry it outside the house. The longer a corpse remains in the house, the more difficult it becomes to drive away the *pālakōĕ'tsa*, whose presence is inimical to the survivors. The o'līa then wash and paint the body all over with red paint; after which it is doubled up, bound in a mat or blanket, and borne away to the family vault or corpse-box, if the hour of noon has not passed. Should a death occur after noon, the body is laid apart by itself some little distance from the house till sunrise next morning. This is the most propitious hour of the day for disposal of the dead, the pālakōĕ'tsa then having all retired to shade-land.[2] The corpse among the Tcil'QĒ'uk was usually stowed away in a large box or coffin, the members of the same family being laid side by side in it. On the exterior of this were painted the family crests or totems, called *salu'līa* (collective of su'līa) = 'the dream objects.' Among these figured the bear, goat, and beaver. Human effigies roughly carved in wood were also sometimes placed near by, similar to those found among the N'tlaka'pamuQ. These family sepulchres differed somewhat in shape according to the social position of their owners. Those of persons of rank and wealth were contained in a boat-like receptacle, the box being placed in the centre. Those which accommodated the remains of the meaner folk were usually rough rectangular boxes. Four days after the disposal of the corpse all who had taken part in the ceremony bathed themselves and cut their hair. They did not cut the hair equally all round their heads. On each side of the head it was cut as far back as, and on a level with, the ears ; beyond this only the tips were cut. The surviving husband or wife never cut his or her hair. Among the Tcil'Qē'uk the severed hair was never burnt, as among the neighbouring Pila'tlq. To do this, they believed, would cause the death of those whose hair was thus destroyed. It seems that they held that things destroyed by fire lost the *essence* of their being, their 'spirit' forms. With them the hair was always carefully buried in some spot where Nature was full of life. This would make the owners of the severed hair safe. All those who took part in the mortuary ceremonies were given 'medicine' by the o'līa to protect them from the evil influence of the corpse. All but the relatives of the deceased were paid for their attendance and service by blankets. If the immediate relatives of the deceased were persons of wealth, a feast would be held on the return of the party from the burial-grounds. If they were poor, this would be held at a later date. It was customary among the Tcil'Qē'uk for friends of the mourning family to bring blankets and lay them on the dead body. When the mortuary feast was given, all those who had thus made presents were paid double of what they had given. The Tcil'Qē'uk had a peculiar custom of tearing off the edges or selvage of the mats and blankets used by the deceased person. This was done to ensure the safety of the surviving relatives and break the power or influence of the *pālakōē̆'tsa*. After the death of a wife the husband must wash his whole body. If this were not done his next wife would shortly die. In performing his ceremonial ablutions he must be careful not to wash in a stream frequented by salmon, or they would shun the stream ever after. He must also abstain from all food for at least a day, and eat sparingly, with his face turned away from everyone else, for a further period of ten or twelve days. His food for the first four days was mainly 'medicine made from herbs, &c. Much the same rule applied to a surviving wife. She must also bind her wrists and ankles with bands of wool. It was also believed by the Tcil'Qē'uk that if the surviving husband or wife bit off pieces of fish and, while chewing it, uttered the name of the deceased, he or she would shortly die. After the body of the dead person had been taken from the house, the o'līa would take quantities of the down of bulrushes and spread it all over the bed on which the deceased had lain. He would then set fire to it, and beat the bed and walls and surviving relatives with *sqol'p* (spruce branches) to drive away the sickness and ghost of the dead. At certain times the sQElā'm would call for mortuary sacrifices. These were always conducted at sunrise. Everyone who had buried a relative or friend would assemble at the place appointed, and bring with them a quantity of choice food and other gifts. These were all given to the SQElā'm, who placed them on a circular table or platform erected for the purpose. In the centre of the circle a large fire was built ; between the fire and the enclosing table was an intervening space. This was for the SQElā'm, the people all standing round outside. When all is ready the SQElā'm enters this ring, and, taking up portions of the offerings, throws them into the fire, offering them as he does so to the manes of the departed. What is left of the presents after the offerings have been made is distributed among the people. The names of deceased persons were never uttered in the hearing of their relatives. They were practically tabooed till given to some of the survivors later at some name-feast. Slaves were never killed at the death or burial of their owners among the Tcil'Qē'uk. They were sometimes sold to defray the expenses of the mortuary feast.

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[1] In view of the recent discussions on totemism it is important to remember that the totems of our northern tribes are merely crests, *i.e.*, visible symbols of unity of the gens or clan. It is the common possession of the privileges and powers the ownership of these implies, not a belief in a common descent from their prototypes, which binds together the individual members of the gens or clan in a mystic union and brotherhood.

[2] It is difficult to obtain any coherent statement from the natives regarding their beliefs or conceptions of the after-life. An individual possesses, it seems, two kinds of bodies, one visible and tangible, the other visible only to an o'līa. This latter—which is given to haunting the scenes of its earth-life, and is specially attracted by its former personal belongings, such as clothes, tools, utensils, &c. (hence the general disposal of these with or about the corpse in burial)—seems to be different again from the soul or spirit with which the SQElā'm deals, and which goes to live in spirit-land. I have found it very difficult, thus far, to get any clear or definite knowledge, if such exists, on these points

Birth Ceremonies.

In most of the ceremonies of the Halkōmē'lEm tribes the emblems of the *Sqoi'aqī* play an important part. At the birth of a child it was the ambition of most parents to have one or more of the members of this brotherhood or totem present to perform the sqoi'aqī dance, and secure for the child the protection of this powerful 'medicine.'[1] A child whose birth was celebrated by the Sqoi'aqī was made thereby a person of social importance. It entitled him to rank later among the notabilities of the tribe. Part of the birth ceremony consisted in the formal washing of the infant by the Sqoi'aqī. It was during the birth-feast that the ears of the child were pierced for earrings. The piercing was done by means of a pointed piece of pitch-pine, the wood being left in the hole to prevent it from closing again. The task was always performed by skilled persons, who were paid for their services by gifts of blankets. The pads or bands for deforming the child's head were also applied on these occasions.

Puberty Customs.

I did not gather much concerning the customs practised by youths on reaching manhood. They went apart by themselves for a longer or shorter time, and fasted, and bathed and exercised their bodies till they had acquired their su'līa. When a girl reached puberty she had to undergo a four days' seclusion. For the first two days she must abstain from food of any kind ; after this she might eat a little dried salmon, but no fresh meat or roots. After the fourth day the girl's face was painted, and she was permitted to walk abroad for a little distance in charge of some woman. On her return four o'līa would meet her and dance round her, each holding a salmon of different species in his hand. When this ceremony was over, she was taken to a lake and made to undergo a ceremonial washing and cleansing. She was never allowed to enter a stream frequented by salmon, or they would shun the stream thereafter. Throughout the four days of her seclusion she was kept busy in making yarn, as among the Sk·qō'mic. While her menses are upon her a woman must never eat hot or fresh foods.

Mythology.

The great transformer and wonder-monger of the Tcil'Qē'uk was called by them *QEQä'ls*. This is apparently the collective form of the commoner Qäls of the other tribes. I was not able to gather much concerning his doings among them. They apparently invoked him in prayer at times. The Tcil'qē'uk formerly possessed a large stone statue of a human being. It was owned by a certain family, and was taken to the neighbouring Sumas tribe by a woman who married into that tribe. The statue weighed over a ton, it is said. A few years ago some enterprising person bought it for a small sum, and shipped it into Washington State, where it figured for a time in a 'dime museum.' It has since found its way, I believe, to the Field Columbian Museum at Chicago. This statue was said to be the work of Qᴇqā'ls, who one day passing that way saw a man and his wife, who in some way displeased him, and were in consequence transformed into stone statues.

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[1] I have given below the Pila'tlq account, which is the fullest yet obtained, of the origin of these emblems. Apparently all the Halkōmē'lEm tribes held members of this totem, who were entitled to the use of its emblems. Among the Kwa'ntlEn as many as 300 of them, I was informed, would assemble together at some of their naming-feasts. From this it is clear the brotherhood or totem was extensive.

Mythical Account of the Origin of the Sī'yak.

In salmon-fishing the Tcil'qē'uk mostly used the *sī'yak*, or salmon-weir. They believe their ancestors were taught how to construct this by *Tā'mia*, the wren. He instructed them on this wise. He bade the limbs of the young cedars (*Thuya gigantea*) twist themselves into withes, and stout branches to sharpen one of their ends to a point and place themselves firmly in the bed of the stream in the form of a tripod, fastened at the top by the withes, two feet being down stream and one up. He then called upon other boughs to wattle themselves in the lower legs of these tripods, till the weir or dam thus formed spanned the whole stream; at the foot of which the salmon soon congregated in great numbers. He bade the people make their salmon-weirs thereafter in like manner.

Origin of the Tlukē'l Su'lïa.

There was once a youth who was undergoing his puberty rites, and seeking his *su'līa* on the margin of 'Cultus' Lake. This lake was the abode of *Slalakum* (*i.e.*, supernatural water-people who lived at the bottom of lakes). One day he took a stout buckskin, and pierced it with many pointed bones. This he fastened about him, and taking a large stone to weight himself with, jumped into the lake. He quickly sank to the bottom. In his descent he came down upon the roof of the Slalakums' dwelling. The inmates were disturbed by his fall, and went out to see what had happened. They found the young man there, and carried him into the house. Presently he came to himself, and looked about him. Among the Slalakum present he perceived some who were sick. Their sickness had been caused by his spitting in the lake, and by the ashes of his fire dropping down upon them. He wiped away the spittle and ashes, and thus healed them of their sickness; and in return for his services they gave him the *Tluke'l*, an object resembling a long stout icicle. He stayed with the Slalakum a little while, and then returned to the surface of the lake again, taking his mystic *Tlukē'l* with him. When he got home all the people at the sight of him were taken sick. He healed them all with his *Tlukē'l*, and became a great Sqᴇlā'm. He was specially able to cure those who fall ill from contact with a Slalakum. The tidings of his adventure and the fame of his skill spread among the surrounding tribes, and a man of the Nᴇk·ā'mᴇn tribe determined to visit 'Cultus' Lake and seek similar or greater powers for himself. Accordingly, in company with a friend to assist him, they set out for the lake. They managed to get there without the knowledge of the Tcil'qē'uk people, in whose territory the lake lies. They had taken with them a stout *stē'qim* (rope). They got out to the middle of the lake, and the man who sought to visit the Slalakum tied the rope about his body and jumped into the water, bidding the other pay out the slack as he descended. He carried a big stone with him, and this caused him to sink quickly. When he had been down a good while the other grew impatient and pulled up the rope, at the bottom of which he was horrified to see the skeleton of his companion. He had been devoured piecemeal by the fish of the lake. Greatly frightened, the survivor hurriedly packed up the skeleton, and made his way home again as fast as he could. Deterred by the shocking fate of this man no one thereafter sought to pay a second visit to the Slalakums of 'Cultus' Lake.

Myth of the Kwākwāli'tsa, or 'Blanket-beating.'

In the very early days of Tcil'qē'uk history the people were once suffering greatly from famine. Leaving the women and children at home the men went down towards the mouth of the river to seek for salmon. When they had gone some miles down the stream they made a dam or weir, and were successful in taking a few salmon. One of the lads with the men then wanted to run back and tell his mother. But this the men would not allow; they were determined to abandon the starving women and children. But of this the lad disapproved, and determined to let his mother know. So he slyly took some salmon eggs and bound them to his leg by means of a piece of bark. He next began to run after butterflies, and he followed one till he got out of the men's sight, and then made straight for home. On reaching there he straightway told his mother what had happened, and what the men intended doing. The mother called together the other women and communicated to them what she had learnt from her son. Upon hearing of the selfishness of their husbands they became greatly enraged, and all took pieces of bark and beat the couches of their husbands with them. They do this kind of thing only when they are very angry. The action has apparently some occult import, the nature of which I could not gather. After this they took the blankets, paint-boxes, and feathers of their husbands, and started off to seek them. As they approached their husbands' camp—ever since named *kwākwālī'tsa*='beating blankets,' in memory of the incident—they beat the blankets of their husbands with sticks, and with loud voices invoked Qeqä'ls to transform their husbands and never let them come home again. Presently the men heard the din the women were making, and seeing their feathers floating towards them on the air, one said: 'Something is going to happen; I see my feather in the air.' 'And I mine,' said another. Each man then saw his paint-feather floating towards him. They then called upon the painter to quickly paint them. He complied with their request, and hurrying at his task, painted one as a wild goose, another as the white-headed eagle, and another as the woodpecker, and others as something else. Meanwhile the angry wives were drawing near. The painter no longer stopped to mix his colours, but painted the remainder of the men some all black and some all white. The women were now upon them; and Qeqä'ls, in response to their prayer, transformed the painted men into birds. They all flew off, and came together again on the Fraser near the Indian village of Oha'mon. Here they met with Sk'lau', the Beaver, who told them of the land of the Salmon people, and promised to go and get the salmon for them, and thus help them to make peace with their wives again.

From this point the story closely resembles that told by the Pila'tlq regarding the origin or presence of the salmon in their waters, which I have recorded below. It will be unnecessary, therefore, to repeat it here.

The Tcil'Qē'uk seem to possess but few folk-tales, or else they have forgotten them, the above being all I was able to gather from my different informants. They are, however, a most interesting people, and the study of their customs, beliefs, and language has been both profitable and instructive.

LINGUISTIC.

In Dr. Boas's brief notes on the Halkōmē'lEm tribes of the Fraser he does not treat of their language at all, except to call attention to the fact that it is dialectically allied to the Kauē'tcin of Vancouver Island. He remarks: 'The language as spoken on Vancouver Island [*i.e.*, the Kauē'tcin] and on the mainland shows slight dialectic differences, the most striking ones being the general substitution of *l* for *n*, and of *ā* for *ä* on Fraser River.'[1] In making this very general statement, Dr. Boas is slightly in error. He has forgotten that a vocabulary of one of the most important and extensive of the River tribes, the Kwa'ntlEn, has been given in the Comparative Vocabularies of Dawson and Tolmie, in which this substitution finds no place at all as far as the interchange of *n* and *l* is concerned, and very little as regards the vowels; and my own more detailed investigations confirm the accuracy of these investigations. There are more important dialectical differences, too, than the interchanges mentioned by Dr. Boas. These will be brought out in their proper place in my treatment of the Halkōmē'lEm dialects.

In choosing the Kwa'ntlEn and the Tcil'Qē'uk, as I have in this report, to illustrate the speech of the Halkōmē'lEm tribes of the Lower Fraser, I was influenced by the following considerations. In the first place, the Kwa'ntlEn are, or rather have been, one of the most powerful and extensive of the River tribes, and their dialect seemed to present some special and interesting features worthy of attention; and in the second, the Tcil'Qē'uk were reported to have formerly spoken a non-Halkōmē'lEm tongue. It seemed wise to me, in view of this fact, to search for linguistic evidence of this report, as a confirmation of it might throw light incidentally upon other important questions.

I may remark in passing that thus far no systematic attempt to elucidate the dialectical peculiarities of the Halkōmē'lEm speech, outside of my own efforts, has been made as far as I have been able to learn. A few hymns and prayers in Yale and Tcil'Qē'uk have been printed by missionary effort; but these, fashioned as they are for the most part rigidly on English lines, do not always afford the student a correct or satisfactory view of the language, or give him any grasp of its syntactical principles and peculiarities. The phonology, too, employed in these productions is painfully lacking in uniformity, as well as otherwise falling short of what one could desire.

In this connection I would like to suggest that the Indian Department at Ottawa might lay linguistic science under a deep debt of gratitude if it would adopt the phonetics of the Reports on the North-Western Tribes of Canada, published in the annual Reports of the Birtish Association, which are employed in these studies, and which have proved themselves to be fairly adequate to their task, and print and circulate them among the missionaries who have charge of the spiritual welfare of the Indians throughout the Dominion. I am given to understand that the Department has asked certain missionaries in British Columbia to make vocabularies of the speech of the tribes amongst whom they labour, and these vocabularies would be infinitely more valuable if an adequate and uniform system of phonetics were adopted and employed by the compilers of them.

In the compilation of these notes I have followed my usual practice and employed two or three Indians together. I have found this to be imperatively necessary. The personal difference in articulation and enunciation, through loss of teeth or the malformation of some voice organ, is sometimes very great. Moreover, the spread and use of English among the Indians is very seriously affecting the purity of the native speech. Frequently they are in doubt about the correctness of some form or phrase, and have to appeal one to the other to know which is right.

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[1] See Ninth Report on the N.-W. Tribes of Canada. *B.A.A.S.*, 1894.

Already the order of their words in the sentence is undergoing modification and approximating to the English order; while the analytical tendency of our language is slowly, but surely, undermining their inflectional pronominal forms. In the mouths of the younger members of the tribe, who have learnt English, the independent pronouns are now not infrequently employed with the verb where only the inflectional forms would be used by the older people. In the course of collecting my notes one of my informants referred repeatedly to the (to him) undesirable particularising character of the native speech, the simpler forms of the English appealing strongly to his mind. Certainly this man was, as his reflections from time to time showed, more than usually thoughtful and observant.

Wherever in my native texts the order of the words follows closely that of the English, it may be suspected that the native purity of the language has suffered. I was not sufficiently alive to this tendency at the first to guard wholly against it.

As my studies of the Kwa'ntlEn gave me a good opportunity for an examination of the niceties of the Halkōmē'lEm verb, I paid greater attention to this feature in that dialect. In Tcil'Qē'uk on the other hand, I have given more attention to the pronouns and demonstratives; thus making one study complementary to the other. My studies of these two dialects have made clear to me many points that were obscure in the Sk·qō'mic. I was not clear on the function of the important particle *kwa* (or *kwē* as it is in that dialect). There is no doubt that *kwa* is an indefinite article, which seems at times to have also a restricted partitive function. This will be illustrated in my notes. Other pronominal, demonstrative, and verbal particles, common to the Salish dialects of this region, which will be treated of in their proper place, have also been better understood and their respective functions grasped by my studies of the River speech.

The Indians most useful to me in my studies of the Tcil'Qē'uk were—'Captain' John, chief of the Sūwä'lē sept; his son-in-law, 'Commodore,' and David SElä'kEtEn of 'Cultus' Lake. I also desire to express my thanks to the Rev. W. Barraclough for the use of his private Tcil'Qē'uk vocabulary; for although his system of phonetics made it necessary for me to get all the words from the Indians over again, his list of words was useful to me in many ways, and was the means of revealing in several instances the presence of synonymous terms, some of which are certainly foreign to the Halkōmē'lEm tongue, and are probably survivals of the older Tcil'Qē'uk speech. My best thanks are also due to Mr. Suart of 'Cultus' Lake for many courtesies extended to me during my sojourn among the Tcil'Qē'uk.

PHONOLOGY.

VOWELS.

a	as in English	h*a*t	i	as in English	pin
ā	,, ,,	f*a*ther	ī	,, ,,	p*i*que
â	,, ,,	*a*ll	o	,, ,,	p*o*nd
ä	,, ,,	gn*a*t	ō	,, ,,	t*o*ne
e	,, ,,	p*e*n	u	,, ,,	b*u*t
ē	,, ,,	th*ey*	ū	,, ,,	b*oo*t

E as in English flow*er*

DIPHTHONGS.

ai, as in *ai*sle; au, as in c*ow*: oi, as in b*oi*l; eu, as in f*ew*.

I found the vowel sounds in Tcil'Qē'uk quite as indeterminate in character as in Sk·qō'mic. The long vowels are more troublesome in this way than the short ones. In the mouth of David SElä'kEtEn *ī*, *ai* and *ē*, as also *ō* and *au*, were constantly interchanging in the most bewildering fashion. At first I was led to think the changes must be due to some law of vowel sequence I had overlooked; but further study of the subject and a comparison of his pronunciation with that of other Indians made it quite clear that these changes were due to no such law, but simply to imperfect and slovenly enunciation. The Indian uses his lips but little in speaking, and this habit affects the clarity of his utterance and causes his vowels to lack precision and definiteness. The short vowels could almost anywhere be substituted for each other; indeed, the same collector will find himself writing the same word sometimes with one vowel, sometimes with another.

CONSONANTS.

I pointed out in my notes on Sk·qō'mic that our division of certain consonants into surds and sonants was not applicable to that tongue. The same remarks apply here. I believe I should be quite within the truth if I asserted that the speech of the coast and delta Salish possessed neither surds nor sonants as we understand those distinctions in English. I gravely question whether their t's, k's, s's and p's are accurately represented by our surds t, k, s, and p (*f* they do not possess at all, nor its corresponding sonant *v*). They seem rather to occupy an intermediate position, and partake of the quality of both surd and sonant. At times this is plainly discernible, and one is at a loss to render the sound accurately. In the tribal name of the Kwa'ntlEn, for example, the *k* is certainly not our *k*, nor is it better rendered by the corresponding sonant *g*. It is rather a rare quality of sound combining both elements. The native *p* is another example. Rarely is it uttered like our *p*, and still less is it our *b*. It can only be described as something between the two, and must be heard in the mouth of a native to be fully appreciated. The native pronunciation of English terms makes it quite clear that some at least of their 'surds' do not correspond to ours; and that, although they have no sonants, as distinct from surds, in their own speech, they yet invariably convert a surd into a sonant when speaking English. For example, David calls bacon, *bagon*; pit he calls *bit*; and bite, *bide*. Veal he pronounces as *beal*, and barrow as *farrow*. These are but a few examples, but they serve to illustrate my point:

I find the following consonantal sounds in Tcil'Qē'uk:—

t, approximately as in English.
t, intermediate between our t and d. (I do not distinguish this from the other.)
k, approximately as in English.
k, intermediate between our k and g. (I do not distinguish this from the other.)
k·, palatised k, almost *ky*.
q, as *ch* in *loch* in broad Scotch.
Q, approximately as *wh* is uttered in North Britain.
H as the German *ch* in *ich*.
h, m, y, as in English.
n, sometimes as in English, sometimes with a suspicion of *l* about it.
l, ,, ,, ,, ,, ,, ,, *n* ,,
s, ,, ,, ,, ,, ,, ,, *c* ,,
ss, as in English *hiss*.
p, rarely as in English; generally intermediate between our *p* and *b*.
c, as in English *sh*; initial and medial.
ç, as *th* in the word *thin*; initial, medial, and final.
tc, as *ch* in the word *church*; initial, medial, and final.
ts as in English Fitz; initial, medial, and final.
kl, as *cl* in the word *climb*; initial and medial.
tl, an explosive *l*, approximately like the *ll* in Welsh; initial, medial, and final.
sl, as in English; initial and medial.

kw, as *qu* in the word quantity; initial and medial. The combination of these two consonants occurs oftener than any other in Tcil'Qē'uk. It is the predominating element of its vocables. Some writers treat them as consonant and vowel. I cannot think this to be correct; *w* is here as much a consonant as the *k* is, being followed in every instance by a vowel.

The consonants in Tcil'Qē'uk are fairly determinate in character. Certain of them, however, show a tendency to permutation; *tc* and *ts* are perhaps the commonest interchanges. I was at a loss for a long time whether to write the tribal name Tcil'Qē'uk or Tsil'Qē'uk. In the mouths of some Indians *s* runs uniformly into *c*. *s*, *ç*, and *tl* are also common interchanges. To mark the hiatus which occurs in the uttering of some words I have employed the apostrophic sign, placed over the word, thus:—Tcil'Qē'uk.

ACCENT.

Accentuation is as marked in Tcil'Qē'uk as in Sk·qō'mic, and as difficult to bring under rule. The most general rule is that which seems to hold good throughout all the Salish dialects, viz., that the accent in a word falls oftenest upon the syllable containing a long vowel. In Tcil'ꞯē'uk the accent seems to play an important part sometimes in the modification of the sense of a word. Thus, in the verb *petamit*, to ask, the accent may fall upon the first or the second syllable. When it falls upon the first the term conveys a sense different from that it possesses when the incidence is upon the second. Thus, when I say pᴇ'tämit-tcil-tca, 'I will ask,' I mean that I will ask 'anybody'; but when I place the emphasis upon the second syllable, thus: pᴇtä'mit-tcil-tca, it signifies that I will ask some certain person I have in mind. Again, it is the accent that marks the difference between certain distributives and diminutives, and augmentatives and diminutives, of common form. Thus, tsᴇk·tsu'k·ut means 'many trees'; but tsᴇ'k·tsuk·ut signifies 'little trees'; sll'sꞯᴇtlp = a big tree, but sllsꞯᴇ'tlp, a little tree.

NUMBER.

Tcil'ꞯē'uk does not appear to possess a true plural. Its place is supplied in various ways; sometimes by distributives and collectives, which are formed by amplification of the stem by reduplication, epenthesis, or diaeresis; and sometimes by a vowel change similar to that which takes place in English when we convert *man* into *men*, *foot* into *feet*, &c.; more rarely by aphaeresis and by the use of a term expressive of 'abundance' or 'plenitude.' The following will serve as examples:—

man	swē'ᴇka.	men	slwē'ᴇka.
woman	slāll.	women	silsā'll.
youth	swē'wilus.	youths	swā'wilus.
maid	k·'āmi.	maids	k·'ā'lami.
horse	stᴇkē'yū.	horses	stᴇlᴇkē'yū.
girl	k·ā'k·ami.	girls	k·akā'lami (diminutives of k·'ami).
boy	swēᴇkā'tl.	boys	wōᴇkā'tl.
son	me'la.	sons	mā'mela.
infant	skā'kᴇla.	infants	kā'kᴇla.
chief	slä'm.	chiefs	yᴇslā'm.
house	lä'lᴇm.	houses	lᴇlā'lᴇm.
dog	skwomai'.	dogs	skwomkwomai'.
hat	yā'suk.	hats	yā'lsuk·.
stone	smält.	stones	smᴇmä'lt.
rat	haut.	rats	keq haut.
mouse	kwā'tᴇl.	mice	keq kwā'tᴇl.

DIMINUTIVES.

lä'lᴇm, house; lᴇlä'm and lē'lᴇm, little house.
mauq, bird; humauq, little bird.
stā'lō, river; stā'tᴇlō, rivulet; smält, stone; semᴇle't, little stone, pebble.

For others, see the Vocabulary.

REDUPLICATION.

Reduplication plays an important *rôle* in Tcil'ꞯē'uk, as in the other Salish dialects. Besides performing the functions of a plural it expresses also intensity, repetition, and prolongation of verbal action; it signifies also, as we have seen, diminution and its opposite, augmentation or increase; also collectivity, depreciation or inferiority, and several other qualities.

INSTRUMENTAL NOUNS.

The familiar instrumental noun suffix *-tᴇn* appears in Tcil'ꞯē'uk as *-tᴇl*, thus:—

mᴇsēil-*tᴇl*, anchor.
tsä'lis-*tᴇl*, seat, chair.
au'q-*tᴇl*, brush.
cūmā'tis-*tᴇl*, dagger.
tlu'k·ꞯ-*tᴇl*, fish-hook.
skwē'-*tᴇl*, ladder.
pᴇ'ts-*tᴇl*, needle.
mē'-*tᴇl*, a helper.

cūl'um-*tᴇl*, belt.
cᴇlᴇwᴇ'tl-*tᴇl*, borer.
stlukᴇlᴇ's-*tᴇl*, button.
cūtᴇ'k'-*tᴇl*, door.
sk·au's-*tᴇl*, kettle.
cūtlā'kᴇls-*tᴇl*, mat.
swᴇ'l-*tᴇl*, net.

AGENT NOUNS.

The prefix of agency *nūks*, seen in the Sk·qō'mic, appears also in the Halkōmē'lEm dialects. In Tcil'Qē'uk we find it under the form *lūks*, thus:—

lūks-kwālē'liH, or *lūks*-mē'tla, a dancer.
lūks-kēkElā'k, a deceiver; *lūks*-E'tcEtc, a stutterer.
lūks-ahā'wa, a hunter; *lūks*-stē'lEm, a singer.

Almost any verb of action may take this prefix, and thus form a noun of this class; but the same idea may be otherwise expressed. Thus I find *E'kwEklē*H, a shooter, from *kwElē'*H, to shoot; ē'wEsaiH, a guide, from ēwEs, to guide, direct, or instruct; su'k·sāk·wai, a fisher, from sā'k·wai, a fish; and lukElu'kEm, a diver, from lu'kEm, to dive. In these latter two we see another of the *rôles* reduplication plays in Salish.

SYNTHETIC AND INDEPENDENT NOUN FORMS.

I have pointed out in previous reports that synthetic or incorporative nouns, as distinct from independent nouns, form a very limited class in the Salish tongues of British Columbia; and that they are apparently restricted to terms expressive of the parts of the speaker's body. In Tcil'Qē'uk these are generally attenuated forms of the corresponding independent nouns. A few, however, are formed from different roots. The following will serve to exhibit their use in Tcil'Qē'uk, and at the same time illustrate the particularity and nicety of certain forms of expression:—

'I hurt my head' (by something falling upon it, such as a bough of a tree, &c.), LĀm-kwEl sqaius; here the noun is the full independent form.

'I hurt my head' (by passing under something, such as a low doorway or bough), tās-Eluk-tcil (synthetic form, abbreviated from independent form, k·ēEk·Eluk, crown of the head).

'I hurt my head' (by accidentally striking it on the ground as I lay down), tās-ā'lukEl-tcil (my vocabulary does not furnish me with the independent form of this noun).

'I hurt my ear,' tās tel k·wōl; *verbatim*, 'hurt my ear.'

'I hurt my left ear,' mauk'tl tEl skä'lia (synthetic form).

'I hurt my right ear,' mauk'tl tEL slä'lia (synthetic form).

'I hurt both my ears,' mauk'tl tEL k·wōlkwōl (independent form reduplicated).

'To wash one's face,' SōQ-*oc*-Em (synthetic form extremely attenuated. This root is seen in the Interior tongues), from SōQä't, to wash. The change in the verb from *-ät* to *-Em* marks the verbal noun or gerund. It has also a causative or active force when the object is specified, as here.

'To wash one's body,' SōQ-*āk*-Em (synthetic form extremely attenuated).

'To wash one's hands,' SōQä-*tcis*-Em (synthetic form seen in all compounds for 'hand' or 'fingers').

'To wash one's feet,' SōQ-H*yil*-Em (synthetic form abbreviated from independent form, ts'kē'Hyil).

'To wash one's head,' SōQ-ē'Ek-Em (synthetic form abbreviated from independent stem, k·ēEk·Eluk).

'To wash one's back,' SōQ-ōwē'tc-Em (synthetic form; independent form wanting in the vocabulary).

'To wash one's chest,' SōQ-ē'lEs-Em (synthetic form slightly abbreviated from independent form, sē'lEs).

It should be understood that every one of these incorporative expressions could be, and often are, rendered by the full form of the verb and the full independent noun, as: SōQä't-tcil tEl tsEā'tsus, I wash my face; SōQä't-tcil tEl ts'kē'Hyil, I wash my feet, &c., &c., but the incorporative forms are the more elegant.

COMPOUND TERMS.

The Tcil'Qē'uk vocabulary furnishes numerous instances of this class of word. The method of formation is very similar to that which obtains in English. The compound may be formed by simple juxtaposition, by agglutination, or by formative elements. Thus:—

tEmkwā'i = famine, *verbatim* 'period' + 'hungry.'
tEmkākā = flood ,, 'period' + 'water' + 'water.'
kElEtsEl = to swear ,, 'bad' or 'evil' + 'mouth' (latter abbreviated).
kākaHyil = lame, from kākai, 'sick,' and ts'kēHyil, 'foot.'
swēEkā'tl = youth, from swēEka, man, and formative particle *ātl*, signifying immaturity or youthfulness.
lūksahā'wa = hunter, from ahā'wa, to hunt, and lūks, formative particle of agency.
sEtltEl = a bailer, from sē'ltcut, to bail, and the instrumental particle tEl.

PARTS OF SPEECH.

There is very little, if any, formal distinction in Salish between the various parts of speech. As the noun possesses no number, no cases, and no formal gender, and the verb no proper conjugations, tenses, or moods, a word may stand without change of form for almost any part of speech. It is the temporary function of a word in a sentence that gives it its distinctive character. Thus the same word may at different times and in different expressions be either a verb, noun, adjective, adverb, preposition, &c. For example, the equivalent of our 'in' in Sk·qō'mic is *ō'is*; thus, *ō'is tE lām*, 'in the house.' But in the following sentence this same ō'is takes on the function and the imperative termination of a verb. Thus: *ō'is-ka tE lām*, 'go in the house.' Again, the adverbs, and particularly the adverb of negation, constantly perform the functions and take on the pronominal and temporal affixes of verbs. Thus: *hau'-Ek mun-k·ō'k·ōt*, 'I will not strike it'; *verbatim*, not-will-I strike; *hau'-it nat-k·ō'k·ōt*, 'we didn't strike it'; *verbatim*, not-we-we-strike. In the former of these two instances the negative has absorbed the temporal affix, and in the latter the personal pronoun, dropping its own final letter; *hauq* being the full and independent form of the negative in Sk·qō'mic. Even the pronominal forms share at times the functions of other parts of speech, and need a personal article to give them definiteness. This is peculiarly the case in regard to the forms employed to indicate the third person. These are in many instances still simple demonstratives, and employed as such in other constructions.

There are, of course, certain compound and other terms to which these general remarks do not apply. There is also a very interesting class of nouns which differ from the corresponding verb forms by the addition of the prefixed sibilant *s*. These are apparently gerundial nouns. In Kwa'ntlEn, in particular, the gerund is thus regularly formed; and any verb may apparently be converted into a noun with verb force in this way. Abstract nouns and perfect participles are formed in Tcil'Qē'uk by this means. In Kwa'ntlEn the ordinal numbers are regularly formed from the cardinals by prefixing *s* to them. In N'tlaka'pamuQ we find much the same. The following examples from the Tcil'Qē'uk will be found interesting:—

ē'wEs, to instruct.	sē'wEs, instruction, learning.
mu'kwEtsEl, to kiss.	smu'kwEtsEl, a kiss.
k·au, to howl.	sk·au, a howl.
hi'kEtl, to hiccough.	cī'kEtl, a hiccough.
e'tltEl, to eat.	se'tltEl, food.
ai'tEl, to fight.	sai'tEl, a fight.
lE'pitc, to send (something).	slEpitc, thing sent.
u'lia, to dream.	su'lia, the subject of the dream.
tām, to shout.	stām, a shout.
Kwats, to see.	skwats, sight.
pēls, to sow.	spēls, seed.
kwElst, to stew.	skwElst, a stew.
häs'Em, to sneeze.	s'hä'sEm, a sneeze.
kē'EqEtsult, to slide.	skē'EqEtsult, a slide.

GENDER.

Grammatical gender of a kind is found in Tcil'Qe'uk. The definite article possesses distinct masculine and feminine forms. Thus: *tE* (masc.), the; *sE* (fem.), the. In a certain sense the demonstratives, which are compounded with the definite article, may also be said to possess formal gender, though it is only a borrowed one. The same applies also to the so-called gender of the possessive pronoun of the first person singular and the personal pronoun of the third person. But, strictly speaking, it is only the definite article which possesses a formal gender; the seeming gender of the other forms arising from their coalescence with this. I did not fully understand this in my study of the Sk·qō'mic, where the pronominal and demonstrative gender is exactly the same as in the Halkōmē'lᴇm tongues, and attributed to these terms, as Dr. Boas had before me, a formal gender of their own. This is clearly incorrect. They possess no true gender of their own; in every instance it is the presence of the accompanying article or demonstrative that gives the gender. Thus, we say *sᴇl tᴇl*, my mother; *tᴇl mᴇm*, my father; *sᴇ la*, she; *tᴇ la*, he; *sᴇ la slā'lī*, this woman; and *tᴇ la swē'ᴇka*, this man; but in every case we are using the definite article, and obtaining our formal gender from it. Every one of these terms is compound; *sᴇl* and *tᴇl* are *sᴇ* and *tᴇ* compounded with the pronominal element *l* (the *n* of other Salish dialects). And in the *sᴇ la* and *tᴇ la* forms we have the same *sᴇ* and *tᴇ* compounded with the adverbial particle *la* (the *na* of other dialects). These latter forms stand, as I have said, equally as pronouns of the third person and as demonstratives. Thus it is clear that there is no true pronominal gender in these Salish dialects, as has been hitherto supposed. Even in the *tŭ'-tla* or *tau'-tla* and *sau'-tla* forms, signifying 'he' and 'she' respectively, we have the same definite article; though its closer coalescence with the other elements of the compound obscures its presence here in some degree.

Besides this formal distinction of gender by use of the article, we find the usual distinction of separate words to denote male and female; thus:—

swē'ᴇka, man.	slā'lī, woman.
swēᴇkā'tl, boy.	kā'k·ami, girl.
swē'wilus, youth.	k·'ā'mī, maiden.
mᴇm or mᴇl, father.	tat or tᴇl, mother.
swā'kuts, husband.	stā'lus, wife.

In speaking of animals, sex is distinguished by placing modified forms of the terms for 'man' and 'woman' before or after the class word, thus:—

dog, swēwē'ᴇka skwomai'; bitch, slᴇslā'lī skwomai'.

In speaking of birds the sex is marked by a special term for the male bird, thus:—All male birds whose plumage differentiates them from the female are called by the term *stᴇ'mtᴇm*; all large birds whose plumage does not markedly differentiate them from the females are called simply *mauk·*, the female being *slā'lī mauk·* (mauk· is the term for 'duck'; it appears to be a generic for 'bird,' as *mī'yits* = 'deer' is for animal); and all small male birds not markedly differentiated by plumage from the female are called *mē'ᴇmuk*; the female, *slā'lī mē'ᴇmuk*.

I have already called attention to the numerous *rôles* reduplication plays in the Salish tongues. In the examples used here to mark gender of animals we have a notable illustration of its elastic character. The reduplication in *swēwē'ᴇka* carries with it a sense of nobility, greatness, superiority, might; while in *slᴇslā'lī* it carries the opposite sense of meanness, smallness, inferiority, weakness. These distinctions are used throughout the whole vocabulary. Anything that is large, strong, fine, or excellent, is *swēwē'ᴇka*, or masculine; anything that is small, weak, mean or contemptible, is *slᴇslālī*, or feminine.[1]

CASE.

I have already said that case distinctions are wanting to the Salish tongues of British Columbia, and the Tcil'qē'uk presents no exception to this rule. The relations expressed by the case endings of the classic tongues are supplied by particles, as in English and other analytical languages. In certain constructions the noun seems to take on modifying suffixes suggestive at first sight of case endings; but this is not really so; these terminations are merely possessive pronominal suffixes. We find the same thing in the Oceanic tongues.

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[1] We have here a fine glimpse of the primitive mind evolving genderal distinctions. Under the conditions of savage life any other view than that taken by the Salish tribesmen would seem to be impossible. Our own Aryan ancestors apparently took the same view, for our grammars of to-day speak of the masculine as the 'nobler gender.' The phrase would appear to be an unconscious reminiscence of earlier and ruder conditions of life.

PRONOUNS.

PERSONAL PRONOUN.

Of these there are in Tcil'Qē'uk three classes: the independent, the inflectional or copulative, and the incorporative. The independent personal pronouns are:—

I, me, tᴇ e'lsa.	we, us, tᴇ tlē'mᴇtl.
thou, thee, tᴇ lūa.	ye, you, tᴇ tlewo'p.

Strictly speaking, the corresponding forms employed for the third person are not pronouns, but demonstratives; but I add them here:—

he (near the speaker), tᴇ lä'.	they (visible to speaker), yᴇ sä'.
he (distant from speaker), tᴇ sä' or çä.	
he (invisible to speaker), kw'tsä'.	they (invisible to speaker), kw'sä ä'tltᴇl.
she (near speaker), sᴇ lä'.	
she (distant from speaker), sᴇ tsä'.	
she (invisible to speaker), kw' sä'.	

Besides these common, regular forms we find the following compounds for the third persons: *Tō'-tla* or *tau'-tla*, he, him; *sō'-tla* or *sau'-tla* or *çō'-tla*, she, her; *tō-tla'-lᴇm*, *sō-tla'-lᴇm*, and *tla'-lᴇm*, they, them. The usage of these as distinguished from the others is very difficult to understand. In some instances they seem to be used in special constructions, in others as simple synonyms for the commoner forms. I spent several hours with David in trying to understand what special usage they had, but was no wiser at the end. None of the rules he sought to lay down for my guidance would stand examination. He clearly did not understand the matter himself, nor did his examples of their usage help me to do so.[1]

The function and scope of the independent personal pronouns seem to be somewhat broader in Tcil'Qē'uk than in the dialects previously examined. They appear at times to take the place of the inflectional forms and become the subjects of verbs; just as if in Latin *ego*, *tu*, &c., were used instead of the terminal inflective forms. I found numerous instances of the kind, but believe it to be the result of the influence which English is exercising upon the native idiom.

INFLECTIONAL OR COPULATIVE PRONOUNS.

It will be remembered that in N'tlaka'pamuQ we found distinct forms for transitive and intransitive verbs. In the Halkōmē'lᴇm tongue, as in Sk·qō'mic, one form only is employed. This in Tcil'Qē'uk is as follows:—

I, -tcil or -tsil.	we, -tcit.
thou, -tcūq.	you, -tcap.
he, -s or -ᴇs.	they, -s or -ᴇs.

Absence of the third persons is marked by the particle *le* (*ne* of the other divisions.) All these forms are modified in the oblique moods. Strictly speaking, the forms given here to the third person are not pronouns, but rather substantive verbs. *See under* Kwa'ntlᴇn.

INCORPORATIVE PRONOUNS.

The method of synthesis here employed resembles that of the N'tlaka'pamuQ more than that of the Sk·qō'mic, with which the Tcil'Qē'uk has most points in common. The object pronoun comes between the verb and the subject pronoun, thus:—

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[1] Since the above was written I have studied the corresponding forms in the Kwa'ntlᴇn dialect, from which it would appear that the function of these forms resembles that of *ille*, &c., in the Latin. *See* the Kwa'ntlᴇn text.

I will help thee, mâit-*tsā'ma*-tcil-tca.
I will help you, mâit-*to'la*-tcil-tca.
Thou wilt help me, mâit-*tsai'*-tcûq-tca.
Thou wilt help us, mâit-*to'l*-tcûq-tca.
We will help thee, mâit-*tsā'ma*-tcit-tca.
We will help you, mâit-*tola*-tcit-tca.
He will help me, mâit-*tsai'k*-Es-tca tEsä'.
He will help us, mâit-*to'lak*-Es-tca tEsä'.
He will help thee, mâit-*tsa'ma*-tca tEsä'.
He will help you, mâit-*to'lam*-tca tEsä'.
He will help him, mâit-Es-tca tEsä'.
He will help them, mâit-Es-tca yEsä'.
They will help me, mâit-*tsai'k*-Es-tca yEsä'.
They will help us, mâit-*to'lak*-Es-tca yEsä'.
They will help thee, mâit-*tsā'ma*-tca yEsä'.
They will help you, mâit-*to'lam*-tca yEsä'.
They will help him, mâit-Es-tca yEsä' tEsä'.

Incorporative forms, just as personal forms, are wanting to the third person.

POSSESSIVE PRONOUNS.

Of these pronouns there are several forms. The simplest is as follows:—

my, 'l.	our, sEa'tl.
thy, E.	your, -ElEp.
his, her, -s.	their, -s,

They are employed thus:—

'l skwomai', my dog.	*sEa'tl* skwomai', our dog.
E skwomai', thy dog.	skwomai'-*ElEp*, your dog.
skwomai-*s*, his or her dog.	skwomai-*s*, their dog.

In some of the Halkōmē'lEm dialects *'l* of the first person singular becomes *tl*, This *l* is the *n* of the other divisions, the most constant and widespread of all the pronominal elements in Salish.

A second, fuller, and more elegant form is obtained by adding the article, thus:—

tEl, my (masc.), sEl, my (fem.); tE...tcit, our (masc.); sE..,tcit (fem.), our,
tE E (masc.), sE E (fem.), thy; tE...ElEp (masc.), sE...ElEp (fem.), your.
tE...s (masc.), sE...s (fem.), his or her; tE...s (masc.), sE...s (fem.), their,

A comparison of these two forms makes it quite clear that the so-called gender of the pronoun is derived from the article, there being no distinction of gender when the article is absent.

A third and emphatic form is:—

'l-swä, my.	swä-tcit, our.
E-swä, thy.	swä-ElEp or E-swäElEp, your.
swäs (tEsä'), his.	swäs (sEsä'), her; swäs (yEsä'), their.

This form is also compounded with the article, thus:—

Singular.	Plural.
tEl-swä (masc.), sEl-swä (fem.), my.	tE-swä-tcit (masc.), sE-swä-tcit (fem.), our.
tE-E-swä (masc.), sE-E-swä (fem.), thy.	tE swäElEp (masc.), sE-swäElEp (fem.), your.
tE-swäs (masc.) his, sE-swäs (fem.), her.	tE-swäs (masc.), sE-swäs (fem.), their.

A still more emphatic form for the first person singular is obtained by repeating the *l* after *swä*. Thus, *tEl-swä-l*, 'my own.' These emphatic forms are used when a comparison of the object possessed by the speaker is made with some other object possessed by somebody else. Thus, if we are discussing the merits of our respective fathers, and I want to state that my father is superior to anybody else's, I use the expression *ō swē'Eka tE-l swä-l mEl*, '*my* father is a good man'; or, better, 'a good man is the father belonging to me.' Again, I may ask to whom belongs a certain house; the owners would reply thus: '*sᴇa'tl*,' 'ours.' I may be incredulous and ask in a doubting tone, '*Swäᴇlᴇp-a*? 'yours'? The reply would then come back, '*Swä-tcit*,' 'yes, ours.'

The above are the regular forms, but they are properly used only when the object spoken of is present and visible to the speaker. Different forms are used when the object is present, but invisible to the speaker, and still different forms when the object is both absent and invisible to the speaker. The following sentences will serve to illustrate all these forms as they are used in Tcil'qē'uk.

	ē swē'ᴇka	'l mᴇm	
		tᴇ-l mᴇm	
First person singular		'l-swä mᴇl	my father (present and visible) is a good man.
		tᴇ-l-swä mᴇl	
		tᴇ-l-swäl mᴇl	

ē swē'ᴇka kwᴇ mᴇm or mᴇl, my father (present but invisible) is a good man.
ē swē'ᴇka kw'sᴇl (ᴇ)mᴇn or mᴇl, my father (absent and invisible) is a good man.

	ē swē'ᴇka	ᴇ mᴇ	
Second person singular		tᴇ ᴇ mel	thy father (present and visible) is a good man.
		ᴇ swä mel	
		tᴇ ᴇswä mᴇl	

ē swē'ᴇka kwᴇl mᴇl, thy father (present but invisible) is a good man.
ē swē'ᴇka kw'sä' mᴇl, thy father (absent and invisible) is a good man.

	ē swē'ᴇka	mᴇls	
Third person singular		tᴇ mᴇls	tᴇsä', his father (present and visible) is a good man.
		swäs mels	
		tᴇ swäs mᴇls	

ē swē'ᴇka kwᴇ mᴇls (tᴇsä'), his father (present but invisible) is a good man.
ē swē'ᴇka kw'sä' mᴇls (tᴇsä'), his father (absent and invisible) is a good man.

The plural is formed regularly in like manner. All these forms imply that the speaker has a personal knowledge of the individual spoken of. If, on the other hand, the person were unknown to him, he would add the particle *tsa* or *tō'-wa* after the adjective; thus, ē tsa swē'ᴇka or ē tō'wa swē'ᴇka, &c.

If the object is of the feminine gender, then, in the place of the above the following forms are used:—

	ē slā'lī	'l	tat or tᴇl, my mother (present and visible) is a good woman.
		sᴇl „	„ „ „ „ „ „ „
First person singular		'l swä	„ „ „ „ „ „ „
		sᴇl swä	„ „ „ „ „ „ „
		sᴇl swäl	„ „ „ „ „ „ „

ē slā'lī ts'ᴇl or s'ᴇl tat or tᴇl, my mother (present but invisible) is a good woman.
„ „ kw'sal tat or tᴇl, „ „ (absent and invisible) „ „ „

Second person singular	ē slā'lī ts'ᴇl tᴇl, thy mother (present and visible) is a good woman.
	„ „ sᴇl tᴇl, „ „ (present but invisible) „ „ „
	„ „ kw'sä' tᴇl, „ „ (absent and invisible) „ „ „

Third person singular	ē slā'lī s'ᴇ tᴇls tᴇsä', his mother (present and visible) is a good woman.
	„ „ sᴇ „ „ „ „ (present but invisible) „ „ „
	„ „ kw'sä' „ „ „ (absent and invisible) „ „ „

The plurals are formed regularly in like manner. Sometimes the 'absent and invisible' form is abbreviated. Thus, I may say *sᴇl skēq skwomai'*, instead of kw'sᴇl, &c., my dog (absent and invisible) is black. I add another example of the use of these 'absent and invisible' forms. I am asked by my neighbour, as I stand at my door or just outside the house, if I have any fish. Should I possess some, I answer: Au-ē-'*kw'sᴇl* sâ'kwai, Yes, I have some fish. Other interesting examples of the use of these particles will be found in the story I have written in the kindred Kwa'ntlᴇn text below.

This particle which marks the 'absence,' &c. of the object is clearly the indefinite article *kwa*. As the presence of the definite article, tᴇ (masc.), sᴇ (fem.), marks the presence of the object, so the indefinite article compounded with the locative adverb *sä* marks its absence. This is a very simple and happy device, and the several functions of these two articles are extremely interesting.

(It will be observed that I have written two forms for 'father' and 'mother' in the first person in the examples above, viz., *tat* and *tEl*, mother, *mEm* and *mEl*, father. Of these the former correspond to our familiar nursery terms 'mama' and 'papa'; the latter are more formal, and correspond to our 'mother' and 'father.')

POSSESSIVE PRONOUN WITH *Verbum Substantivum*.

tla or kla l swä lä'lEm.	it is my house.
tla or kla E swä „	„ thy „
„ „ swäs „	„ his or her house.
„ „ sEä'tl or swätcit lä'lEm,	„ our house.
„ „ swä'ElEp „	„ your „
„ „ swäs „	„ their „

To these forms may be added the adverbial particles expressive of 'nearness' or 'distance,' as the object is near to or distant from the speaker. Thus:—*tE ē la*, 'this,' 'near'; *tE ē*, or *tE ē lē* or *lē ti* or *tE lē ti*, 'that,' 'distant'; *tE lē tlā'la*, 'that,' 'very distant.'

If the person claiming the object is not quite sure whether it is his or not, in answer to the question: 'Whose is this?' he would reply *tla tō'wa 'l· swä*, &c., 'I fancy it's my,' &c.

It is permissible to use *tla* with any of the possessive forms; it is not confined to the *'l swä* form only, as given here.

SUBSTANTIVE POSSESSIVE PRONOUN.

These forms are apparently the same as the emphatic forms of the possessive pronoun. Thus:—

'l swä, mine, sEä'tl or swätcit, ours.
E swä, thine, swäElEp, yours.
swäs (tEsä' or sEsä'), his or hers, swäs (yEsä'), theirs.

In like manner with the other forms, they can be compounded with the definite article, thus:—*tEl swä*, &c., &c. If the object spoken of is invisible or absent, then the particles kwa or kw'sä' are added. Thus: *'l swä kwa*; *'l swa kw'sä'*, &c.

SUBSTANTIVE POSSESSIVE PRONOUN WITH *Verbum Substantivum*.

tla or *kla 'l swä*, it or that is mine; *tla* or *kla sEä'tl* or *swätcit*, it or that is ours.
„ „ E swä „ thine; „ swä'ElEp „ yours.
„ „ swäs (tEsä)(sEsä'), it or that is his or hers; *tla* or *kla* swäs (yEsä) it or that is theirs.

Possession or ownership is also marked in Tcil'Qē'uk at times, thus:—

skwomai'tcil, I have or own a dog; skwomai'-tcit, we have or own a dog.
skwomai'-tcũq, thou hast or ownest a dog; skwomai'tcap, you have or own a dog.
skwomai'-s, he has or owns a dog; skwomai'-s (yEsä), they have or own a dog.

A prepositional form is also used of the third person when the owner's name is given; thus: tE skwomai' *tla* John, it's John's dog, or the dog of or belonging to John.

INTERROGATIVE PRONOUNS.

who? wät? or tla-wät? wät tcũq? who are you?

tla-wät kw'sēt tE swēyil? who made the daylight?

whose? tō-wät? tōwät tEsä'? whose is that? tōwät yāsuk tE ē la? whose hat is this?

what? stam? what is that? stam sä'? what do you want? stam kwa stlē?

which? tE lE'tsa? or ElE'tsa? which is yours? ElE'tsa kwa swä? This last term, *tE* or *ElEtsa*, is the numeral 'one' with the definite article or the interrogative vowel *E* added to it.

REFLEXIVE PRONOUN.

self, lamot (*cf.* nōmōt of the Sk·qō'mic).

DEMONSTRATIVES.

tE (masc.), sE (fem.), the ; tE la (masc.), sEla (fem.), this ;
tE sä' (masc.), sE sä' (fem.), that ; yE sä', those.

These latter forms are generally, though not exclusively, employed to point out persons. When the object is other than a person the following forms are commonly used :—

tE ê la, this (object in speaker's hand or quite close to him).

tE ē ti, this (object near speaker). This is sometimes shortened to tE ē.

sä lê ti lä'lEm, or sä lä'lEm lē ti, that house (object little distance from speaker).

sä lä'lEm lē ti tla la', that house (yonder in the distance).

If object be very distant, then the last syllable *la* is drawn out on a rising tone.

sä lä'lEm lē ti tla l . . . a tcâk·Q, that house (far over there on the very verge of sight).

This latter term *tcâk*·Q appears also in such expressions as the following :— ē-tcit tcâk·Q, 'we are far off yet,' said when two or more persons are travelling together towards some distant point, and one asks the other how near they are to their destination. I cannot find distinct forms of demonstrative to mark the plural. The object always does this in Tcil'Qē'uk, never the demonstrative.

ARTICLES.

DEFINITE.

tE (masc.), sE (fem.), the.

I have termed this form 'definite' to distinguish it from the form *kwa*, which I have, for lack of a better term, called the 'indefinite' article; but neither of these expressions is really satisfactory or adequate. TE is frequently used where we should employ the indefinite article; and neither term corresponds very closely to our 'the' and 'a' or 'an.' It will be seen that this article has the same form as one of the demonstratives. I do not feel at all certain that the particle which marks the noun, and gives it its gender, is identical with that which accompanies the pronoun and demonstratives. The common form may be misleading. If, however, one may judge by the analogy of the Oceanic tongues, which, it may be remarked, possess articles with manifold functions similar to the Salish, it may be that we are here dealing with one and the same particle. Speaking of the various functions of the article in Melanesian, Codrington remarks on this head : 'It can hardly be doubted but that it is the demonstrative particle so conspicuous in pronouns and adverbs.'[1]

INDEFINITE AND PARTITIVE ARTICLE.

Kwa ; a, some.

The true character and function of this particle may best be gathered from the following illustrations of its use. I found the study of its various functions extremely interesting. Stam *kwa* stlê? 'What do you want?' Its employment here marks the lack of definite knowledge in the speaker's mind of what is wanted. Tlawä't *kw*'sē't tE swē'yil? 'Who made the daylight?' Here it accompanies and coalesces with the verb *sēt*, 'to make or create,' and shows that the questioner has no definite knowledge of the action. The same function is seen in the next sentence: SētEs *kwa* tcī'tcil Siä'm tE la tEmu'q. 'God created the world.' The time of the action is indeterminable; hence the presence of *kwa*. ElE'tsa *kwa* swä? 'Which is yours?' The function here is obvious. Wiä'ts *kw*Els kā'kai. 'I am often sick.' Its presence here is necessary to mark the indefiniteness of the time when the speaker is sick.

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[1] *The Melanesian Languages*, p. 108. Oxford, 1885.

Lē wEtl·kai *kw'*El mEl? 'Is your father dead?' Here the particle merely marks the absence of the subject. 'l-stlō *kwa* k·â, 'I should like some water'; 'l-stlō *kwa* stEkē'yū, 'I should like a horse'; auä-â-stlēs *kwa* smī'yits? 'would you not like some meat?' The function here resembles that of a partitive article. KElä't *kwa* lEtsa, 'another'; *verbatim*, 'again a one.' Yä'swa *kwa* läm tE e'lsa, 'perhaps I'll go.' Here the uncertainty of the act is marked. Hutâ *kw'Es* läms, 'he said he was going.' Here it is the absence of the person spoken of. Numerous other examples will be found in the native text below.

NUMERALS.

Of these the simple independent forms are :—

1. lE'tsa.
2. lsä'la.
3. tlēuq.
4. HEHätsEl.
5. tl'k·häsEl, s'k·ätsis.
6. t'qEm.
7. tsauks.
8. t'kä'tsa.
9. tūq.
10. â'pEl.
11. â'pEl kEst (E) lE'tsa.
12. „ „ lsä'la.

The 'teens' follow in like manner.

20. ts'kwē, tsEkwē'q.
21. ts'kwē kEst (E) lE'tsa.

The other units follow regularly in like manner.

30. c'lca.
40. HEtsElca.
50. tlEkslca.
60. t'qEmca.
70. tsûksElca.
80. t'k'sEloa.
90. tūqElca.
100. lä'tsElwEts.
1000. â'pEl lä'tsElwEts.

PARTITIVE NUMERALS.

half, s'uk; quarter, stauk·; three-quarters, tlēuq stauk·.

Class numerals abound in Tcil'Qē'uk. The following are examples:—

1 man lā'lEtsa.
2 men yâ'isila.
3 „ tl'Qä'la.
4 „ Hätsl'la.
5 „ s'kätsa'la *or* tl'kätsa'la.
6 men t'qu'mela.
7 „ tsauksa'la.
8 „ t'kä'tsala.
9 „ tū'qEla.
10 „ â'pala.

	Canoes.	Stones, &c.	Trout, &c.	Round things. Apples, potatoes, &c.	Long things. Poles, pencils, &c.
1	lE'tsaQEtl	lE'tsus	lE'tsäuk	lEtsis	lE'tsamets
2	sâ'maQEtl	lsä'lus	yisä'luk	lsu'lis	ilsi'lamets
3	tlEqEtl	—	—	—	—
4	musä'tl	—	—	—	—

	Hats.	Houses.	Trees.	Blankets, &c.
1	lE'tsawok	lE'tsōtōQ	slE'tsatlp	lalE'tsa
2	tsā'mok	sE'mEtōQ	slsä'tlp	lsi'la

ORDINALS.

first, *yūwe'l*; second, *tūtE's* (*ad litt.* 'next').

All the forms following are periphrastic, and grow more cumbersome as they proceed. They are formed on the principle of the nursery rhyme, 'This is the house that Jack built.' Thus the 'third' is a phrase equivalent to 'next-to-the-next-to-the-first.' The others follow in like manner till the last is reached, which is *tsīyau'k·t.* In the matter of the formation of its ordinal numbers the Tcil'Qē'uk differs very much from the Kwa'ntlEn, which has specialised forms (see below under Kwa'ntlEn Numerals).

DISTRIBUTIVES.

These are formed from the cardinal numbers by reduplication of the first syllable; thus:—

one to each,		lEtslE'tsa	six to each,		t'qt'qE'm
two	„	lyEsE'la	seven	„	tsEtsau'ks
three	„	tlūqtlū'q	eight	„	t'ktE'kätsa
four	„	HāHä'tsEl	nine	„	tEtū'q
five	„	tl'ktl'kä'tsis	ten	„	â'pEpEl

ADVERBIAL NUMERALS.

once, lE'tsauq.
twice, sama'tl *or* çama'tl.
thrice, tl'Qa'tl.
four times, HätsEla'tl, tlEsmutla'tl.
five times, tlEkätsa'tl, s'kätsa'tl.

six times, t'qEma'tl, *or* —aç.
seven times, tsauksa'tl, *or* —aç.
eight times, t'kätsa'tl, *or* —aç.
nine times, tuqa'tl, *or* —aç.
ten times, âpEla'tl, *or* —aç.

ADJECTIVES.

The adjectives are of two kinds, simple or primitive, such as 'good,' 'bad,' &c.; and derivative, that is, those formed from nouns or verbs. The place of the adjective in composition varies somewhat with the construction of the sentence in which it is found. The simple attributive and numeral adjectives invariably occupy much the same position as in English. Thus: 'a fine day' is *ē swē'yil*; 'a bad season,' *kEl tEm*; 'two stones,' *lsä'la smält*; 'many hats,' *keq yā'lsuk*. Occasional exceptions are found to this rule. The place of the predicate adjective is the exact opposite of the English. Thus: 'my dog is black' is *skēq tE* 'l skwomai'; *verbatim*, 'black the my dog.' 'The moon is bright' is *stä'tū tE tl'kelts*; *verbatim*, 'light the moon.' 'Our house is old' is *sā'lakwa tE lälEm-tcit* (or *sEä'tl lälEm*); *verbatim*, 'old the house our.' The pronominal adjective always accompanies its noun, coming immediately before or after it.

COMPARISON OF ADJECTIVES.

The comparison of adjectives is in Tcil'Qē'uk effected in the following manner:—

Positive	Comparative		Superlative
ē *or* ē'ya, good	stEtE's *ē* (*ad litt.* near good) tûtE'st *ē* (*ad litt.* next to good)	better	yûwe'l, best.
	klautis tE ē (*ad litt.* close to good).		

The comparative is not a regular construction as in English or Latin; for, in addition to the expressions above, the term *yūwe'l* is also used. This word is the adjective numeral 'first.' When this term is employed the distinction between the comparative and the superlative is a purely vocal one. The degree of comparison is marked by the manner in which the word is uttered. The higher the degree of goodness or excellence, or the opposite as the case may be, the more the tone rises and the longer the final syllable is drawn out. This method of comparison is common to all the Salish dialects; is indeed common to all primitive tongues. It is the same method little children use in their speech with one another.

ADVERBS.

The position of the adverb varies with the class employed. The temporal adverb is invariably placed at the beginning of the sentence. Examples of its syntax will be found in the native text.

VERBS.

The verb is inflected by means of affixes and auxiliary verbs. The aorist is formed by prefixing the particle *lᴇ*, *le*, or *lē*. Sometimes the first syllable of the verb stem is also reduplicated. The perfect is a compound of particles and auxiliary verbs *lᴇ* . . . *wᴇ-tl-hai* . . . The simple future is formed by suffixing the particle *tca* or *tsa*. The particle *lᴇ* is also sometimes used in a future as well as in a past tense. This seeming double and contradictory usage is due to the fact that in the Salish tongues tense distinctions, as we understand them in English or the classic languages, are totally unknown. Speaking strictly, there is no 'time' to any Salish verb. In contemplating an action the 'place' only, never the 'time,' is considered. The action or state in the native mind is always 'present' or 'absent,' 'here' or 'there,' never 'now' and 'then.'

This is the reason why we find the same particle marking the 'past' in one dialect and the 'future' in another. Each is equally 'absent' or 'there,' the context making it clear which 'there' is intended, a 'past' or a 'future' one. This is a very interesting feature of the Salish verb and explains very simply how *ne* or *nᴇ* can be applied both to a past and a future action or state without confusion. It is of interest to note that the Halkōmē'lᴇm dialects only, apparently, use this particle in its double sense. Several of the interior dialects confine its usage to the 'future' alone, while the Sk·qō'mic and some other Coast tongues employ it strictly to mark 'past' actions and states. This particle is primarily an adverb of location signifying 'there.' It is the same particle which appears so often in the Salish dialects as the sign of the third person 'absent.' The reason is obvious.

Kā'kai, sick.

PRESENT TENSE.

Singular	Plural
Kā'kai-tcil, I am sick.	Kā'kai-tcit, we are sick.
Kā'kai-tcŭq, thou art sick.	Kā'kai-tcap, you are sick.
Kā'kai tᴇ la, he is sick.	Kā'kai yᴇsä, they are sick.
Kā'kai sᴇ la, she is sick.	

AORIST.

Singular	lē-tl-tcil-kā'kai, I was sick.
	lē-tl-tcŭq-kā'kai, thou wert sick.
	lē-tl-kā'kai (tᴇsä'), he was sick.
	lē-tl-kā'kai (sᴇsä'), she was sick.
Plural	lē-tl-tcit-kā'kai, we were sick.
	lē-tl-tcap-kā'kai, you were sick.
	lē-tl-kā'kai (yᴇsä'), they were sick.

A second aorist or indefinite past is also used, the difference in meaning between which and the former is not perfectly clear to me.[1] Thus:—

Kā'kai-e-tl-tcil, I was sick. Kā'kai-e-tl-tcit, we were sick.

The other persons follow in like manner.

PRESENT PERFECT CONTINUOUS AND RESPONSIVE FORMS.

ē-tcil-kā'kai, I have been and am sick; ē-tcit-kā'kai, we have been and are sick. The other persons follow regularly in like manner.

FUTURE TENSE.

Kā'kai-tci -tca, I shall be sick.	Kā'kai-tcit-tca, we shall be sick.
Kā'kai-tcuq-tca, thou wilt be sick.	Kā'kai-tcap-tca, you will be sick.
Kā'kai-tca (tᴇ sä), he will be sick.	Kā'kai-tca (yᴇ sä'), they will be sick.
Kā'kai-tca (sᴇ sä'), she will be sick.	

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[1] Since this was written I have studied the Kwa'ntlᴇn verb. The difference there is due to the *time* of the state or action; one form is used of recent events, the others of more remote. See the Kwa'ntlᴇn verb below.

Läm, to go.

läm-tcil, I go.	läm-tcit, we go.
läm-tcūq, thou goest.	läm-tcap, you go.
läm, he goes.	läm, they go.

Aorist.

lē-tcil-laläm, I went.   lē-tcit-laläm, we went.

The other persons follow regularly in like manner.

Here the verb stem is reduplicated.

Present Perfect Continuous Tense.

ē-tcil-läm, I am going.   ē-tcit-läm, we are going.

The other persons follow regularly in like manner.

Past Perfect Tense.

lᴇ-tcil-wᴇ-tl-hai-läm, I have been; *ad litt.* I have finished my going.
lᴇ-tcit-wᴇ-tl-hai-läm, we have been; *ad litt.* we have finished our going.

The other persons follow in like manner.

The auxiliary verb *hai* in this compound is used also independently, and signifies 'to complete' or 'finish' anything.

Future Tense.

läm-tcil-tca, I shall go.   läm-tcit-tca, we shall go.

The other persons follow regularly.

Dubitative Form.

yä'swa kwa läm tᴇ e'lsa, perhaps I may go.
yä'swa kwa läm tᴇ lū'a, perhaps thou mayest go.
yä'swa kwa läm (tᴇ sä'), perhaps he may go.

The plural follows regularly.

Imperative.

läm-tla! go!
laēyil! go away! ē-kwᴇs-läm, 'you'd better go.'

The position of the inflectional pronoun in the Halkōmē'lᴇm is worthy of notice. In Tcil'qē'uk the pronoun is seen to be sometimes prefixed, at others suffixed to the verb stem; thus:—

kwa'kwᴇs-tcil, I am warm; qait-tcil, I am cold.
tcil-kā'ka, I am drinking; tcil-kā'ka tᴇ kā, I am drinking water.
ē'tutᴇm-tcil, I am sleepy; kē'sel-tcil, I am tired.
tcil-kwa'kwᴇl, I am talking; tcil-kāl, I believe.

In some of the Salish dialects the pronoun is uniformly prefixed, in others as uniformly suffixed. The Halkōmē'lᴇm tongue seems to occupy a middle position. I am not satisfied that the pronoun may be *indifferently* prefixed or suffixed in this tongue. At times this would appear to be the case; but in many instances the position of the pronoun affects the sense of the verb. An illustration will make this point clear. We will suppose I wish to borrow my neighbour's horse: I say to him as we stand together, *kōt-tcil tᴇ stᴇkē'yū*, 'I am going to take your horse.' In such instances as this the verb root always precedes the pronoun; but if I had taken the horse without his knowledge and afterwards met him I should say: *tcil-kōt tᴇ stᴇkē'yū*, 'I took your horse.' Again, if he had missed the horse and asked, when I was by, who had taken it, I should answer *lᴇ-tcil-kōt*, 'I took it.' Here the particle *lᴇ* marks the action as done formerly. I have already briefly spoken of the functions of this particle in Halkōmē'lEm. A few illustrations of its use here will be of interest. In Tcil'Qē'uk its functions are not quite the same as in some of the neighbouring sub-dialects. In the contiguous Pilā'tlq, for example (as in the SnanaimuQ of Vancouver Island, according to Dr. Boas), *lE* or *le* or its equivalent *ne* is regularly used in the present tense. Thus: *lE-tcil-kā'kai*, I am sick, *lE-tcit-kā'kai*, we are sick. And the past or aorist is *lē-ç-tcil-kā'kai*, I was sick, *lē-ç-tcit-kā'kai*, we were sick. This is not the case in Tcil'Qē'uk. Although it appears at times in what seems to be a present tense and is usually translated by our present tense, strictly speaking it can never be considered as a present tense form. Even in the Pilā'tlq and such dialects as use it regularly in the present tense forms, although the expression 'I am sick,' &c., is given by the Indians themselves as the equivalent of lE-tcil-kā'kai, it does not rightly express the sense of the native idiom. Its use in TcilQē'uk makes this quite clear. It is more than kākai-tcil 'I am ick.' For with the statement of present sickness is conveyed also the statement of *past* sickness. *LE-tcil-kā'kai* signifies rather 'I have become sick,' a state or condition which came out of the past, unknown to, or rather in the absence of, the person to whom the invalid is talking, and continued down to the present moment. It was the 'absence' of the interlocutor of the patient when the state began that brings the particle of 'absence' here in the present tense. This is clear from the following use of it in Tcil'Qē'uk. Thus I say in this dialect *tcil-kāl*, 'I believe,' to any first-hand statement made directly to me; but if the statement was first made to someone else in my 'absence' and afterwards told to me by another person I then say *lE-tcil-kāl*, 'I believe.' Thus in speaking of Scriptural statements the form *lE-tcil-kāl* is always used. The following expressions show a different usage again for this particle in Tcil'Qē'uk, and further illustrate the change of position of the inflexional pronoun. We will suppose I have determined to go hunting. I am preparing for the task and a neighbour drops in and asks me what I am going to do. My answer in such an instance would always be: *lE-tcil-ahā'wa*, 'I am going hunting.' Here *lE* marks *future* action. It is necessary here because the action is 'absent' or 'there.' I have started; I am in the forest; another person meets me and asks: 'What are you doing?' The proper reply this time is *ahā'wa-tcil*, 'I'm hunting.' I continue the hunt; I come upon my game; the gun is at my shoulder; I am on the point of shooting; a third friend happens along at this moment and says: 'What are you doing?' I respond this time thus: Etcil-ahā'wa, 'I am just going to shoot.' I have been hunting for some time, it may be; I am tired; I sit down to rest; another friend comes along and says: 'What are you doing?' This time I answer, *ē-tcil-ahā'wa*, 'I have just been hunting.' I have returned from my hunt; I am met again by someone who asks, 'What have you been doing?' I reply now, *lē-tl-tcil-ahā'wa*, 'I have been hunting.' I am at home again, and the person who first accosted me comes in and remarks: 'You've got back.' I answer, *lE-tcil-wE-tl-hai-ahā'wa*, 'Yes, I've finished my hunting.'

These examples bring out some of the niceties of the Halkōmē'lEm verb as seen in Tcil'Qē'uk, and show us at the same time how *l*E or *n*E has in some dialects come to mark 'past' and in others 'future' action or state.

Examples of Tcil'Qē'uk Syntax.

this house, tE ē la lā'lEm; these houses, tE ē la lElā'lEm.
that house, tE lē ti lā'lEm; those houses, tE lē ti lElā'lEm.
that hat, tE lē ti yā'suk; those hats, tE lē ti yā'lsuk.
these two hats, tE ē la yIsā'muk *or* yIsā'la yā'suk.
right eye, cwūyā'lus; left eye, ckwā'lus; both eyes, cwai'yElus.
right ear, sIyā'lIa; left ear, c'k·wā'lIa; both ears, k·wōlk·wōl.
right hand, c'yē'wus; left hand, c'kwē'wus; both hands, tEltā'lō,
right foot, c'Hyil; left foot, c'k·oHyil; both feet, c'HEHyi'l.
one dog, lE'tsa skwomai'; two dogs, Isā'la skwomai'.
many dogs, keq skwomai'.
few dogs, au'a ke'qEs skwomai' *or* qā'la skwomai'.
all the dogs, muk· skwomai'.
some dogs, skwomkwomai'.
no dogs, auI'ta skwomai'.
one hat, lE'tsa yā'suk *or* lE'tsawok.
two hats, yisā'la yā'suk *or* sā'mok.
many hats, keq yā'suk.

few hats, au'a ke'qEs yā'suk *or* qā'la yā'suk.
all hats, muk· yā'suk.
some hats, yā'lsuk.
no hats, auī'ta yā'suk.
any hat (a circumlocution).
one house, lE'tsa lä'lEm *or* lE'tsôtôQ.
two houses, sE'mEtôQ.
many houses, keq lä'lEm *or* keq-autQ.
few houses, au'a ke'qEs lä'lEm. *ad litt.* 'not many houses.'
all houses, muk· lä'lEm.
some houses, lElä'lEm.
no houses, auī'ta lä'lEm.
any houses (a circumlocution).
one stone, lE'tsus *or* lE'tsa smält.
two stones, yisä'lus *or* isä'la smält.
no stones, auī'ta smält.
few stones, au'a ke'qEs smält.
some stones, smEmält.
any stones (a circumlocution).
all stones, muk· smält.
many stones, keq smält.
one tree, slE'tsatlp.
two trees, sī'satlp.
a small tree, slisQE'tlp.
a large tree, slī'sQEtlp.
many trees, tsEk·tsu'k·ut.
little trees, tsE'k·tsuk·ut.
no tree, auī'ta skât.

These 'tree' forms are specially interesting, showing as they do three distinct radicals in the same dialect. The numeral form is common to most, perhaps all, of the Salish dialects. It is clearly an old form.

this is John's dog, tla swäs John skwomai'.
which is your horse? ElE'tsa kwa swä stEkē'yū?
he stole my horse, lE la-kä'lsEs 'l swä stEkē'yū.
he stole your horse, lE la-kä'lsâm E swä stEkē'yū.
he killed my dog, lE kaiEtEs tEl skwomai'.
he killed your dog, lE kaiEtEs E skwomai'.
my dog is lost, lē-ē'k·QEs tEl skwomai'.
the man is walking, tE ē'mEç.
the man was walking, lē-tl-l-ē'mEç.
the man will walk, lE-tca-ē'mEç.
your horse is white, pEk tE E-stEkē'yū.
come with me, mē'tla EskEkâ' tla e'lsa.
come home with me, mē'tla le tāk·Q tla e'lsa.
I will go with you, läm-tcil-tca.
this is not my hat, läts 'l swä yā'suk *or* au'a tla 'l swä yā'suk.
God made the world, çī'tEs kwa tcItcil slä'm tE la tEmuq.
Is your father dead? lē wE-tl-kai kwEl mEl?
Is your mother dead? lē wE-tl-kai sEl tEl? If parent be unknown to questioner, *tō-wā'* is added to the expression.
Is he coming? ē-wE-tl-ya-mē? If object be behind the speaker, who looks back as he speaks, then he uses the form *ē-tō-tl-ya-mē?*
Are you coming? ē-tcūq amē?
I am often sick, wlä'ts kwEls kā'kai.
I am not often sick, au'a wlä'ts kwEls kā'kai.
They are coming now, ē-autlī amē' tlalEm.
He is coming now, ē-tautlī amē'.
I am striking it, ē'-tcil-kwā'kwakwot.
He lives with me, tla 'l (swä'l) ts'Qolmuq.

I have spoilt it, kElkEl(E)-lō'q-tcil. In this term we see the particle *nūq* that plays so important a part in the Sk·qō'mic verb under the form *lōq*. It does not appear to enter so largely into verbal forms in Tcil'Qē'uk as in Sk·qōmic. In the Halkōmēlen dialects it has the function of a definitive or determinative.

As I have given a large number of phrases and expressions in the kindred Kwa'ntlEn as well as some continuous text, I have limited the number here. Enough is submitted to show the characteristic differences in the two sub-dialects. I have collected vocabularies and phrases from some of the other River tribes of this division, but the differences between these and those here given, though interesting to myself, are perhaps not of sufficient importance to warrant their publication at this point of my studies.

GLOSSARY OF TCIL'QĒ'UK.

Terms of Consanguinity and Affinity.

Consanguineal ties among the Tcil'Qē'uk appear to extend a generation farther back than those of the other tribes examined. The terms of direct relationship used by them are as follows:—

great-great-great-great-grandparent, tā'miyuk·
great-great-great-grandparent, ō'kwiuk·
great-great-grandparent, tsō'piyuk·
great-grandparent, tsā'muk·
grandparent, = sē'la = grand-child.

When addressing a grandparent or grandchild the forms *sīs* (masc.), *t'sīs* (fem.) are employed. Grandchildren taken collectively are called *mē'mEts.*

parent, tEcswē'; parents, swcā'lī.
child, me'la; children, mâ'mela.
father (speaker's own), mäm; (other people's), tEl.
mother „ „ tât; „ „ mEl.
(my) son (tEl) me'la; (my) daughter (sEl) me'la.

Sex is here indicated by the gender of the article compounded with the possessive pronoun *'l.* Children or family, mâmelis; first child, su'ltla (me'la); second child, tū'tiss (me'la); third child, tistlQä'lEs (mela); last child, tsEâ'sūk·t (me'la).

Brothers, sisters, and first cousins are called by the same term, viz., skâk·. They distinguish between 'elder' and 'younger' in two ways. First and commonly by a lengthening or drawing out of the vowel when an 'elder' is indicated; secondly and less commonly, by the addition of the term sisâ'sEl or sitlâ'tEl, thus: sisâ'sEl tEl skâk·, my elder brother, &c.

Brothers and sisters taken collectively are termed *s'kEla'k·* when younger, and sä'tlEtEl when older, than speaker. Apparently a person's cousins were older or younger than himself, as his father was older or younger than his uncle, the relative ages of the persons spoken of not being taken into consideration. My informant explained it thus: 'If my father is older than my uncle, my cousins are all "younger" to me.'

On the death of a parent the cousinship is loosened, and cousins are thenceforward called sEl tEl, swilmai'tl; or, more fully, le kai, sEl (fem.), tEl (masc.) swilmai'tl; *verbatim,* 'he is dead, my swilmai'tl.'

uncle, cwumElē'k·Q *or* sQumElē'k·Q; aunt, t'scwumElē'k·Q, &c.

When addressing them these terms are shortened to lēk·Q.

aunt's husband
uncle's wife } sQûtcä'pEts *or* cûtcä'pEtc.
uncle's wife's { sister's
aunt's husband's { brother's } child, tē'wEl (masc.), stē'twEl (fem.), stEtē'wEl (coll.).
brother's wife, smâtū'ktil; sister's husband, tsū'tatl.
brother's wife's
sister's husband's } relations, skwo'lūis.
step-father
step-mother } tctlī'läm.
step-son
step-daughter } tûtuqme'la.

CORPOREAL TERMS.

head	sqai yus.	chest	sē'lis.
crown of head	k·ēEk·uluk.	stomach	kōe'la.
back of head	tE'psum.	heart	tsā'la.
forehead	kwō'muls.	lungs	slakōemā'la, spE'lE-Qom.
jaw	sumkai'Etsum or sumqai'EtsEl.	bone	sâm.
chin	slEpai'EtsEl.	hand	tcā'liH.
tooth	yeli's.	finger	slu'qtcis.
nose	mu'ksil.	first finger	mutase'mEl = 'pointer.'
nostrils	slEk·wE'l'Eksil.		
point of the nose	spQo'ktsil.	thumb	mōkwā'multcis.
mouth	tsâ'tsEl.	elbow	somkwilā'qil.
upper lip	stlEtla'itsEl.	leg (whole)	sqE'la.
lower lip	stlEpai'EtsEl.	thigh	spEtā'lEp.
throat	c'wE'lsis.	lower leg	cōHwā'qyil.
windpipe	kō'kōktlitl.	ankle joint	spusōkHyil.
neck (fore part)	skwe'ltlitl.	foot	ts'ke'Hyil.
neck (back part)	tE'psum.	toe-nail	k·wōQul'Hyil
back	stlu'kawitl.		
breasts of a woman	stlukwō'lis.	arm	tâ'lū.
teats	cumâ'.	arms	tEltā'lū.
face	tsEâ'tsus.	finger-nail	k'wōqūoltcis.
side of the head	swē'Ela.	little finger	tsâsūk·tā'latcis = 'youngest.'
hair of the head	mā'kEl.		
hair of face	kwōliē tsEl.	shoulder	cwēlamāla = the carrier.
hair of body	kwē'los.		
hair of animals	tsâ'i.	knee	skEpā'lsitEl.
tongue	tō'qtcitl or tō'qcis.	knee-cap	kepā'lokHitEl.
ear	k·wōl.	ankle	kwō'mokHyil.
eye	ku'lum.	toes	slu'k·Hyil.
eye-brows	tsâ'mEl.	big toe	mokwā'melkHyil.
eye-lashes	tlu'pEtEl.		
pupil of the eye	k·ēqâ'los.		
skin (human)	kwElō'.		
skin (of animals)	kwElō's tE smI'yEts (literally skin-his-the-deer, smIyEts = deer; under this term all the larger quadrupeds are included).		

Terms applied to the principal Animals, &c., known to the Tcil'Qē'uk.

ant (*Formica sp.*), yhâ'IsEm.
bat (*Vespertilio subulatus*), pētspasElā'kEl.
beaver (*Castor canadensis*) s'kElau'.
bear (*Ursus americanus*) (black), spāts.
" " (brown), kwEye'uq.
" *horribilis*) (grizzly), kwētcil.
bee (*Apis sp.*), sIsEmai'a.
" (bumble) (*Apis sp.*), mo'kmok.
butterfly (*Papilio*) (all large kinds), sEsqa'.
" " (white), pēpEk·aiā'sa.
" " (medium and small-sized), âpai'EsEl.
crow (*Corvus caurinus*), spEpEtâ'l. The sound uttered by these birds resembles the sound of the word *skak* = 'brother' in Tcil'Qē'uk. They believe he is trying to claim relationship with them when he cries skak ! skak !
chipmunk (*Tamias striatus*), pi'tsiya.
cougar, panther (*Felis concolor*), cwō'wa.
crane (*Grus canadensis*), smō'k·wa.
deer (*Cariacus columbianus*), k·l'kti'la.
duck (*Anas boschas*), mauq.
dog (*Canis sp.*), skwomai'. A native species was formerly bred for the hair, which was woven into blankets, &c.

eagle (*Haliaëtus leucocephalus*), spâ'kus.
„ „ *sp.*), skwäleq.
elk (*Cervus canadensis*), kaiyē'Etc.
flea (*Pulex irritans*), tâ'tetlEm.
fly (*Musca domestica*), Qōqwlâ'ya.
„ „ *sarcophaga sp.*), qōQai'a.
frog (*Rana sp.*), pēpaho'm.
goose (*Anser sp.*), k·wōme'lakel, âqâ.
ground-hog (*Arctomys caligatus*), skwē'Eka.
grasshopper (*Caloptenus sp.*), kükawatē'lE. Name refers to the strident noise the insect makes.
„ „ tsatsaklē'm; from tsa'klEm: to jump, hop.
hawk (*Accipiter sp.*) (large), Humqē'mEls.
„ „ (small), Hêqemqê'mEls.
„ „ , sē'kElEtc.
horse (*Equus sp.*), stEkē'yū. Introduced since the advent of the whites.
jay (blue), *Cyanocitta stelleri*), kwä'ē.
kingfisher (*Ceryle alcyon*), ts'tcilä'.
lizard (*Lacertilia*), sEyla'H.
oolachan (*Thaleichthys pacificus*), swē'Ewu.
otter (*Lutra* (*Latax*) *canadensis*), skät'.
owl (*Asio accipitrinus*), tclē't'muq.
pigeon (*Columba fasciata*), hâmâ'.
rabbit ('jack') (*Lepus americanus Washingtoni*), skEkûwä'ts.
rat (*Mus sp.*), haut.
robin (*Merula migratoria*), s'kûkōka'q.
raven (*Corvus corax principalis*), skau'Eks.
salmon, 'spring' (*Oncorhynchus tschawytscha*), swē'itcel.
„ 'sockeye' (*O. Nerka*), su'k·ai.
„ 'silver' or 'cohoe' (*O. Kisutch*), kō'kwats.
„ 'dog' (*O. Keta*), kwa'lōq.
„ 'humpback' (*O. Gorbusca*), hō'lia.
„ 'steel-head' (*Salmo Gairdneri*), kē'uq.
„ trout (*Salmo sp.*), k·ōsē'tc.
sturgeon (*Acipenser transmontanus*), skwâ'witc.
snake (*Coluber Lin. sp.*), E'tlkai.
snipe (*Gallinago sp.*), skäsl'a.
spider (*Aranea sp.*), kusku'sitsEl = 'the weaver,' from kai'sitsEl = to weave.
swan (white) (*Orlor columbianus*), cwō'kEl.
seal (hair) (*Phoca vitulena*), ä'cuH.
trout (speckled) (*Salmo sp.*), stEqâ'tc or sEHâ'ts.
„ (white) „ „ slau'kwEts.
weasel (*Putorius erminea*), cletsa'm.
wolf (*Canis lupus occidentalis*), tEkai'ya.
woodpecker (*Picus*) (large red-headed), tEme'tlepsEm.
„ „ (medium-sized), tsēk·'t.
„ „ (small red-headed), sHük.
„ „ (small), tsu'tEm.
wild cat (*Lynx fasciatus*), s'k'tsâ'mEs.
wren (*Troglodytes domesticus*), ta'mla.
„ „ *hiemalis*), „

Glossary of the Commonest Terms used in Tcil'Qē'uk.

able, can, katä'stō.
able, I am, katä'stō-tcil.
above, tcl'tcitl.
abuse (to), kElä'tEs.
  I abused you, kElatsâ'ma-tcil.
ache, pain, sâ'im.
  my head aches, sâ'im tEl sqai'yus.
across, tä'kwEl.
admire (to), tci'lEmit.
admit (to), kwotau'Ht.
  I admit, kwotau'Ht-tcil
adopt (to), sk·ōmē'tl
  I adopt, sk·ōmē'tl-tcil.
  'my adopted child,' 'l sk·ōmē'tl.
advice (good), sē'wEs.
advise (to), ai'yat *or* yät.
  I advise you, yät-sâ'ma-tcil.
  I will advise you, yät-sâ'ma-tcil·tca.

afternoon, le hai tEq swēyil, *or* lailau tEq swēyil = 'the midday is ended or past.'
again, kElä't.
aid, help (to), mêt *or* mait.
I will help you, mait-sâ'ma-tcil-tca.
aim (to), mâ'it.
air, breath, spâ'lEQom.
alder tree (*Alnus rubra*), Hē'tsElp.
all, muk·.
alone, wEhähī'ya.
always, s'tEâ', wīä'ts.
amusement, fun, ē'yis.
anchor, mEsē'iltEl.
anger, stâ'iyuk·.
angry, mad, smä'mitsEl.
animal, smī'yits = 'deer,' sometimes 'bear.'
another { kElä't kwa lE'tsa = again a one.
tE lE'tsa = the one.
answer (to), lûHtE'lEkut.
I answer, lûHtElEkut-tcil.
anybody, muk·a.
apple, kwEâ'p.
apple tree (*Pyrus sp.*), kwEâ'pEtlp.
approach (to), tEsE'tsut.
I approach, tEsE'tsut-tcil.
arise (to), QI'liH.
I arise, QI'liH-tcil.
arouse, QIt.
I arouse, QIt-tcil.
ashamed, qEē'qa.
I am ashamed, qEē'qa-tcil.
ask (to), pE'tämit and pEtä'mit. The first form with accent on first syllable is used when one is going to ask some unknown person; the second when the speaker has in mind the person he is going to ask; thus, pEtä'mit-tcil-tca, Captain John, I'll ask Captain John (when I see him); but pE'tämit-tcil-tca, I'll ask somebody (when I get there).
asking, pE'tEm, pEtE'm.
astonish (to), lûwä'tl.
astonishment, slûwä'tl.
ashes, embers, cwēE'kōila.
ashes (dead), yi'stEl, cwEyistEl.
autumn, tEm hēlä'luH.

This season was marked among the Tcil'Qē'uk by the departure of the salmon.

awl, stl'kau'itEl.
axe, s'k·wo'kum *or* k·wo'kum.

bad, k·El.
bail (to), sē'ltcut.
I am bailing, ētcil-sē'ltcut.
bailer (instrument), sEtltEl.
bait, mä'la.
bake (to), sk·wo'lEm.
bark (to), klâ'wEls.
he barks, klâ'wEtEs.
bark (of tree), pelīē'wus.
basket, sī'tEl.
beach, ēllē'tsEl.
beat, thrash (to), kwâ'lEkwâiEtl.
beautiful, ē'E, ē'yE.
be born (to), kwâl.
bed, cwâ'mut, cwē'tut.
beg (to), lûksmâ'mEl.
below, down, k·lep.
below or down stream, tlEtlä's.
belt, cwī'umtEl.
bench, chair { tsä'listEl, tsältcimel.
cwtsä'litstEl.
bend (to), pâ'it.
I bend, pâ'it-tcil.
bent, crooked, spâ'pi.
berry, tsêm.
beware (to), kwâ'kwElEH.
big, large, great, hêq.
billow, yâ'litca.
bind up (to), qōkwē'wEt.
I bind up, qōkwē'wEt-tcil.
birch-tree (*Betula sp.*), sû'kōmī.
bird, mäq *or* mauq = (duck).
" (small), humäq.
bite (to), k·ē'kwut.
" (a), k·ē'kwom.
bitter, sä'sEqum.
black, skēq.
blackberry (trailing) (*Ribes sp.*), skō'lmoq.
blanket (native), swô'kwatl.
" (modern), sEē'tsum.
bleed (to), tsäluk·hom.
bleeding, tsä'lQom.
blind, k·ē'Equs.
blister (a), kutsâ'm.
my hand is blistered, kutsâ'm tEl tcä'lī.
blood, tsä'tsIEl.
blow (to), p'ât.
blow! pâ't-tla!
I blow, pâ't-tcil.
blue, smEts *or* cmEts.
blueberry (*Vaccinium sp.*), li'tcēlEtc.
blunder (in speech), mElmElai'çEl.
I blundered, mElmElai'çEl-tcil.
blush (to), kwī'mEl.
she is blushing, etcmEkwī'mEl.
blunt (of tools, &c.), kEl-ä'ts.
" (of poles, &c.), kEl-ä'suksEl.
" or pointless, tE'mkwoksEl.
boil (a), sk·wōtsum.
" (to), stlātkwum.
the pot's boiling, le stlatEkwum.
bold, brave, sImIQol.
I am a brave man, sImIqol-tcil swē'Eka.
bore (to), cālt.
I bore, cālt-tcil.
borer (instrument), cElEwE'tltEl.
borrow (to), tcE'tlta.

both, yäsil(E)-tcit.
we'll both go, yäsil(E)-tcit-lâm-tca.
bottle (modern), cwHlämä'la.
„ (made from salmon skin), cwilEsä'la.
„ (made from sound of fish), HIQolä'wa.
„ (made from bear-gut), k·u'k·ē cwilEsä'la.
bottom, cū'Etcilits.
bought, nE-sI'tla.
I bought, nE-sitla-tcil.
bow (to), lē'akwusum.
I bow, lē'akwusum-tcil.
bow (a), tō'qwätc.
bowels or guts, k·uk·ē'.
bowl, ckā'kElum.
box, k·wā'k·Qa.
boy, swēEkâ'tl.
boys, wôEkâ'tl.
braid (to), tEmE'Ht.
branch (a), tsâI'qt.
bread, sEpli'l.
break (to), (strong rope, &c.), tuk·Q.
„ (wood, &c.), luk·Q.
„ (or split into two flat things), puk·Q.
„ (or split round things), suk·Q.
split it into two! puk·watla!
break up, destroy, kElkElē'lt.
breathless, winded, tl'stcēâstcEl.
bridge formed from small log, cûta'tEtl.
„ „ „ big log, cûta'tl.
bright, dazzling, klau'Ekum.
bring (to), mi'stuq.
„ back (to), k·E'lstoq.
I will bring it, k·E'lstoq-tcil-tca.
broken, spEpē'uk.
brush, auqtEl.
buck-skin, ä'qElkEl.
build (to), sēū'tūom.
bundle (a), tsē'um.
burn (a), tsāk·.
„ (to), yu'kut.
burnt (an object), yuk·Q.
burnt up, sEq.
bury (to), pilt.
bush (small), QI'QEl.
„ (big), tsu'tsakut.
button, stlukElE'stEl.
button-hole, stlū'tlukElEstē'la.
buy (to), ē'lEkut.
he is buying it, ē'lEkuls.
by-and-by, Qôa'tsEà.

call (to), tâm.
calm, quiet, slēE'k·wEl.
can, able, katā'stō.
I can, katā'stō-tcil.
candle, slucyEl yĕEkwēyil, or shortly, sluç yĕEkwēyil = marrow of the thigh bone. When the natives first saw tallow candles they thought them to be sticks of slucyEl, or marrow, and attempted to eat them, hence the name.
cane (a), kwElkē'lum.
canoe, slukwE'tl.
camp, k·E'lEmEl.
careful, tsEhē'tsut.
I am careful, tsEhē'tsut-tcil.
carrot, HIâ'wEk (name of a native root resembling a carrot).
carry (to), kwilä't.
carve (to), Qōē'tsI.
carving (a) portrait, Qōē'tsI.
cast, throw (to), lEmi'lstōq.
catch, take, kōt.
cedar (*Thuya gigantea*), Häpâi.
cellar (or root-house having sloping roof), skautsä'la.
„ (native, a hole in the ground with flat roof), skwämä'la.
certain, sure, sEē't, k·äl.
chair, tsä'listEl, tsaltcimEl, cutsa'lits tEl.
change (to), ēyä'kut.
charcoal, p'Etst.
chase (to), run after, ai'stEm, wâwE't·lEtEm.
cheap (to buy), sE'mIya.
„ (easy to acquire), lI'luk.
cheat (to), ėhai'Eluk.
chew (to), tsäm.
„ it, tsät.
chief, sIä'm.
„ (war), stâ'lmiq.
chiefs (collect), yEsIä'm.
two chiefs, sIyä'm.
child, slē'likEtl.
chip, tE'mEl, k·ō'k·mEl.
choke (to), by external pressure, kwumtla'lt.
„ „ by swallowing, tuk·Qēles.
I am choking, tuk·Qē'lEs-tcil.
he's choking, le tuk·Qē'lEs (tE tsa).
chop (to) with axe, tâ'kwels.
chop or fell a tree, yâ'kut.
he's chopping down the tree, yâ'yEk·uls.
cinders, paiē'tc'p.
circle (a), stElä'k·u.
clay (pipe-clay), stau'ok·.
clear (of water), lūqai'yim.
„ (of sky), luk·auk·.
climb (to) (a tree), k·wē.
„ (a mountain), k·wē'EkEl.
close, tEsu'tsut.
come close, mē'tla tEsu'tsut.
cloud, cwātsitEl.
coffin-box, sinä'kwa.
cold, qaitl qait
comb, slitsē'mEl.
come (to), mē
„ arrive, tätcil.
I am come, tcil-tätcil
companion, comrade, sIē'ya.
compassion, pity, tsō'kamit.

compel (to), tcE'cit.
  I will make him go, tcE'cit-tcil-tca-lâm.
contest, race, â'wiltel.
consider, recall (to), hä'kwilis.
cooked, ripe, kwEl.
corpse, spälakwē'tsa.
cottonwood, tcEwo'lp.
crab-tree, kwEap.
crooked, bent, spâ'pl.
  very crooked, spl'pl.
crush (to), klêEk·'t.
crutch, staff, k·au'a.
cruel, kulät.
  he is a cruel man, kulä'tEs tE swē'ka.
cry (to), qüm.
current, leqô'm.
cut (to), kli'tsut.

dagger, cûmâ'tistEl.
daily, every day, mok· swâ'il.
dance (to), skwâiē'liH, mētla.
dancer, lukskwâiē'liH, luksmē'tla.
damp, tcü'tctcum.
dark, tsät.
darling, dear (applied by a mother to her baby boy), êyE'sik.
  „ „ (applied by a mother to her baby girl), êyEs.
dawn, mEtä'wil, mitä'tEwil.
daybreak, luksä'lâwil, mêwâ'wlyil, mEwē'yil.
day, swē'yil.
decayed, pä'kwEtsEt.
deceive (to), kē'kEläk.
deceiver (a), lûkskē'kEläk.
dead, skâ'kai.
deaf, klu'k·wila.
deep, lû'stlEp.
deer-hide, ä'qElkEl.
descend (to), klEpē'l.
descend (to) a flight of steps, cû'tlEpel.
desire, wish (to), stlē.
  'I want some water,' 'l-stlē kwa k·a.
  'I want to drink,' tEmētltEl kwa k·a.
  'I'm dry,' skâkElectcil.
destroy, break, kElkElē'lt.
devour, li'piyhum.
difficult (to do), k·lē.
different, läts.
dig (to) with the hand, HaukQē'ls.
  „ „ a stick, &c., skä'luq.
dim, stlâ'tl.
dirty, supq.
'dirty-face,' su'pqos; a nickname.
disappear (to) suQ, le suQ, 'he's gone.'
  suQsuQ-tcuq, you disappeared.
  suQsuQ-tcil, I disappeared.
dish, trough of cedar, skwe'lstEl.
dish (small) of maple, kamō'molp latsEl.
dish, hēq lä'tsul = big plate.
disappoint (to), mälk.
  you disappointed me, mElkElsä'tl-tcuq.
  I disappointed you, mElkasä'ma-tcil.
discover, find (to), sukElau'q.
  I found a gold mine, le-tcil-sukElauq tE gold mine.
distribute (to), ä'um.
  I will distribute it, ä'um-tcil-tca.
dive (to) lu'kEm.
diver (a), lukElu'kEm.
diviner, seer, u'lia.
dizzy, sE'lus.
door, cûtE'kEtEl *or* cûtE'k' tEl.
down of geese, &c., skai'yus.
drag (to), Qō'k·wEt.
dream (coherent) u'lia.
  „ (incoherent), ulu'lia.
  „ 'totem,' su'lia.
  my dream 'totem,' 'l su'lia.
drop or fall down (to) of person, tsulk·.
  „ „ of object, wE'tsutl.
drown (to), kwoss.
  he's drowned, kwoss kwEsä'.
drum (a) made from skin, kwä'tQum k·âwi't. This instrument was formed very much like a tambourine.
drum, board and stick, kâwi't.

each, tE lEtsa = the one.
earth, temu'q.
eat (to) etltEl, li'pik.
  he is eating it now, le ci'lpikEs *or* li'pikEs.
easy (to get), li'luk.
echo, swilwä'läm.
eddy, tltE'm.
elder tree (*Sambucus racemosa*), kwai'kelp.

enemy, cEmä'l.
enough, hai.
  I have had enough, or I have finished, tcil-hai.
enough, lots, muk.
  muk-tcil, I have lots.
enough, lEts = 'no more.'
escape (to) of an animal from a trap, sEwe'lks.
  „ of a man or slave, k·lē'â.
evening, Qulai'Elt.
expect (to), kōkwo'tskwots.
  I expect, kōkwo'tskwots-tcil.
extinguish, put out (to), tlu'kwilt.

fade (to), ē'k·wom.
fall (to), hē'lEm,
fall, stumble (to), tsElk.
famine, tEm kwâ'i = hungry time.
  I am hungry, kwâ'kwâi-tcil.
far, tcâq.
fasten (to), k·ō'sit.
fat, lâs *or* los.

fear, sisI.
I am afraid, sisI-tcil.
fearless, aua sI'sI-tcil = no fear I.
feather, celts.
feel (to), kutqEt.
fell (to) a tree, ȝā'kut.
yā'yEkuls, ''he's felling a tree.'
fern (*Pteris aquilina*), pItā'k·um.
fern root, ,, ,, sâak.
fight (to), aitEl.
file (a), sā'mEls smält = a grinding-stone.
,, (to), hai'Ekult.
fill (to), lEtsut.
find, discover, sukElauq.
I have found a gold mine, le-tcil-sukElauq tE gold mine.
finish, complete (to), bai.
fir (red), lā'iEtlp.
,, (white), tâlQ.
,, (Douglas), k·ok· wâ'iyĕliHyEtlp.
fire, hai'uk·.
fire-place, swâ'Ekôila.
firewood, cI'ätl.
fire-drill, cū'lcEp.
make a light, cū'lcEp-tla.
fish (to), sâ'tsak·wai.
I am fishing, ē-tcil-sâ'tsak·wai.
fish, sâ'kwai.
fish-bone, s'q'walis.
fisher (a), su'k·sâk· wai.
flame, cwâ'tEkum.
flat, lEk·ē'lup.
flesh, slē'uq.
float (to), pEpâ'k·Q.
flood (a), tEm kâkâ = water-time.
flow (to), lEHō'm.
flower (a), spä'kum.
fog, skwô'tum.
follow (to), tclElât.
tclElat-Es, he's following after, or he's coming behind.
food (ordinary), se'tltEl.
,, (left over from a meal), skĕ'läm.
ford, cuksuksaQom.
fragrance, êyä'lEkup.
freeze (to), pē'witEm.
fresh, qaus.
finger, ēlu'qEl.
fun, amusement, ē'yis.

gamble (to), lēlâhä'l.
I gamble, lēlâhä'l-tcil.
gambling-stick, slEhä'l.
gather, collect (to), k·Epu't *or* k·'pu't.
ghost, spirit, pālakwē'tsa.
girl (little), sEllä'tl.
,, (young), k·âk·ā'mi.
girls (little), sisEllä'tl.
,, (young), k·ak·ā'lami.
give (to), akwust, ä'am, sisyu'qtca.
glad, hēluk·.
gloomy, kē'lus.
glove, tskwâ'lEtsa.
good, ē, ē'yE.
good-bye, lEmâ'wus.
grass, sâ'QEl.
great, large, big, hēq.
greedy, Qô'mutsEl = 'quick mouth.'
green, skwai.
grind (to), sharpen (of edged tools), yu'kust.
groan (to), â'Elsut.
,, (a), â'lsut.
grow (to), tsē'sum.
group, sk·Ekē'p.
grumble (to), kōkwElkwälem.
you are grumbling, kōkwElkwälemtcuq.
guide, direct (to), ē'wEs.
guide (a), ē'wEsaiH.
gum, pitch, kwē'Eq.

hail, sk·ûk·was.

Term has reference to noise made by the hail falling on their roofs.

handsome, aiyā'miç.
hard, k·läq.
harden (to), k·lEQE't.
hark, lō'HlEläm.
harrow, rake, sqēk·apē'lEp.
hat, yâ'suk.
hats, yâ'lsuk.
hate (to), Hē'qEtsEl.
I hate you, Hē'qEtsElmEsä'ma-tcil.
he, him, tôtla, tEsä'.
heal (to), ä'yEluHt.
healer (a), ä'yEluHtsamiç
hear (to), tsatskläm.
heavy, Qô'tus.
help, aid (to), mēt *or* mā'it.
I will help you, mait-sä'ma-tcil-tca.
helper (a), mē'tEl.
hemlock-tree, mElEmE'ltlp.
hiccough (to), hi'kEtl.

This term has a suspicious resemblance to the English; this is due simply to the fact that both are imitative of the sound.

hiccough (a), s'hi'kEtl.
hide (to), kwäkwIl'l.
I am hiding, kwäkwIl'l-tcil.
,, an object, kwä'liH.
hill, skwākwEp, smä'mElit.
hire or engage a person, yū'k·mEt.
I will hire you, yū'k·mEt-sä'ma-tcil-tca.
hold (to), kwilä't.
hole (round), skōkwä'.
,, (long), skōqwē't.
hollow, cwō'tkōal.
hook (fish), tlu'k·QtEl.
home, cwāmEts.
homesick, tātākwE'lmEl.
hop, jump as a grasshopper, tsū'klEm.

horn, tsē'ctEl.
hot, warm, kūakwus.
house, lä'lEm.
houses (collect.), lelä'lem.
  row of houses, stEla'utQ.
house (small), lē'lEm.
howl (to), k·au.
  ,, (a), sk·au.
huckleberry, skâ'la.
hug (to) around the body, kâ'lūwEt.
  ,, around the neck, kä'lust.
hurry (to), Qom = quick, sharp.
hunt (to), large game, kutl, ahä'wa.
  ,, small game, ē'kwalaH.
husband, swä'kuts.
  When addressed by wife she calls him *lau*.

I, tE elsa.
ice, spē'ū.
Indian, Qu'l'mūq.
infant, skâ'kEla (collect., hâ'kEla).
instruction, learning, sē'wEs.
interpret (to), Qē'tsEkEl.
invite (to), am.
itch, tlä'tlEts.

jealous, tâiq.
joke (to), skōkwElak.
  I am joking, skōkwElak-tcil.
journey (to), lEkä'lEkEl.
  ,, (a), lEkä'lEkEl.
jump, hop, as a grasshopper, tsä'klEm.

'keekwilli-house,' skEmE'l.
keep (to), kwila't.
kettle (of basketry), sk·au'stEl.
  ,, (of wood), sçEma.
kind, k·wâ'kwEl.
kiss (to), mu'kwetsEl.
  ,, (a), smu'kwetsEl.
knead (to), tsâ'ium.
kneel (to), skutlqäm.
knife (small), slä'st'sEl.
  ,, (large), tlâ'tstEl.
  ,, (pocket), hē'he Ek = 'breaking' knife.
knit, stā'tikEl.
knock (to) at a door, kwâ'kwōtsEn.
  ,, (to) or strike, kwō'tEsEm.
knocking (n), kwâ'kuäkwEls.
know (to), tläkE'lūq.

ladder, skwē'tEl.
lake, qā'tca *or* Hā'tca.
lame, kākaHyil = sore foot.
land, earth, temu'q.
language, skwEltEl.
lantern, torch, slä'kut.
large, big, hēq.

laugh (to), lēyEm.
laughing, älē'lium.
lay oneself down (to rest), tlâ'kast.
lazy, s'ō'mit.
  he's lazy, s'ō'mit, tō'tla.
  a lazy boy (little), sâmā'mit.
  you lazy boy, sâmâ'mit-tcuq.
leak (to), pēpoq, skuElâ'tsyuq.
  It's leaking, pē'pūQom.
leaf, tsâ'tla.
lean, thin, stits.
leap (to jump over), tsâtlāmits.
learn (to), tâlt.
learning, tatē'il.
  ,, instruction, sē'wEs.
learned, tE'luq.
leather, kwe'lō.
leave (to go), â'iyil.
  I am going le-tcil-â'iyil.
  I am going QEtl-lam-tcil.
lend (to), tsu'lta.
length, stätEtl.

Literally this term means a 'fathom' or the span between the outstretched arms of the average man from the tip of the second finger of one hand to the tip of the corresponding finger of the other. The intermediate lengths are the ¾ fathom, called *sli'maqul tE tätl*, and the ½ fathom, called *skätmē'lis tE tätl*. These are respectively got by bending one forearm towards the chest and measuring from the point of the elbow across to the tip of the finger of the other hand as before, and by putting one hand to the centre of the chest and measuring from this point to the finger of the other outstretched arm, as in the other instances.

level, smooth (of the ground), luk·ē'lup, ēyē'lup.
liar, cūmä'tsilkEl.
lice, mi'qtsEl.
lick (to), tsē'mEt.
lie down (to), â'qEts.
life, clē'yEs.
lift up (to), QE'liH.
light (daylight), stā'tū.
  ,, (of moon), s·kwEHyäs, slE'kelts.
  ,, (of stars), cūHau'kQ.
  ,, (of torch), slä'kut.
  ,, (of weight), Qā'Qa.
lightning, qElu'k·t.
line, s'tē'Hyum.
litter, rubbish, skE'lEp.
little, small, ämē'mEl.
live (to), äi'yilūH.
liver, tsu'lEm.
log (in the forest), s'yä'uk.
  ,, (,, water), kwEtlä'i.

logs, kwEtlkwEtlI.
„ a jam of, s'tuk·tuk·.
lonely, hä'hē.
lonesome, stätē'l.
long, k·lāk·'t.
lose (to), ē'k·Q.
loud, luksçē'akEl.
lover, ts'ā'i, sI'ya.
lump (a), skwâmōq.
lungs, spE'lEQom.

man, swē'Eka.
men, sIwē'Eka.
maiden, k·'ā'mi.
maidens, k·â'lami.
marrow, slucyEl.
make (to), sēt, çēt.
maker (a), in course of formation, tE swäs sIai's = *verbatim*, the his work; when task has been performed, lc hai = *verbatim*, he has made or finished it.
maple (white) (*Acer macrophyllum*), k·Emō'etlp.
„ (vine) (*Acer circinatum*), sI'tsElp.
married man, sä'atcûk [swē'ka].
„ woman, swā'wākuts [slā'lI].
mark (to), qātst.
marsh, luqmā'mElits.
„ (cranberry), mā'kwom.
mask, sQōi'EQē *or* sqoi'EqI.
mat (for bed), slā'QEl.
„ (for floor or seat), tlâ'k·ElstEl, cūtlâ'k·ElstEl.
match, cū'lcEp = name of an old native fire-drill.
cū'lcEp-tla! make a fire or light!
mate, sk·â'hyil.
me, tE elsa.
mean, slâlts.
measure (to), cūēQElē'mEls.
„ (a), QēlEm.
meat, smI'yits.
medicine, stelmûq.
meet (to), if coming from same starting-point, k·â'k·ā'tEl.
„ if coming from different starting-points, lük·smâstEl.
melt (to), from action of sun, yēt.
„ „ „ fire, yē'tEt.
mend, patch (to), pōwē't.
message, yâ'tsēlEm.
midnight, tuk slät.
mind, skwä'lawEl.
mine, 'l swä, tE'l swä.
miss (to), ukwElūq.
mistake (to), mElmEl.
„ (a) (in speech), mElmElai'çul.
mix (to), mu'lEkwot.
mock (to), lōqōhā'kut.
moccasin, stlū'kEHyil, skE'lEHyil.
moon, skwE'Hyäs, slEkä'lts.
morning, lä'tEtl *or* lä'tEç.
come in the morning, mē'tcuq lä'tEtl, or shortly, lä'tEtl-tcuq.
morning star, wâwIē'l-kō'asEl.
mound, heap, skwâ'kwEp.
mount (to), tsEē'lEm.
mountain, sismä'lt.
move (to), tâiH.
„ some part of the body, slowly, kai'Eqsut.
„ all parts of the body, quickly, kwEk·lutsut.
„ from place to place, sila'latl, tē'tēkEl.
much, many, kaq.
murder, kwä'lōs.
murderer (one person only killed), kwä'lōs.
murderer (several persons killed) kwil-kwä'lōs.
muscles, klEē'mEl.

naked, tlāwē'tsa.
name, skwIH.
narrow, kwaē'Ek·s.
near, next, stEtE's, tûtE's.
needle, pe'tstEl.
needy, poor, s'tEsa's.
net, swE'ltEl.
next, s'pätlē'Ek; *verbatim*, none between.
night, slät.
no, au'a.
not, au'a.
none, aui'ta.
noon, tuk swē'yil.
now, tEla, kä'is.
Just now, käis.
nut, s'çē'tsum.

offer (to), â'kwEt, sā'tust.

My informant told me the latter term was not true Tcil'Qē'uk but Snanaimo; but as Snanaimo is a Halkōmē'lEm dialect we may see in the term â'kwEt an original Tcil'Qē'uk word. It is likely that many old Tcil'Qē'uk terms will be found in my collection.

old, clā'lEkwa.
old man, clā'lEkwa (tE swē'Eka).
old woman, clā'lEkwa (sE slā'lI).
orphan, we'lEm.
outside (of anything), sut'lkā'lawEtl.
„ (a door), sut'lkā'tsEl.

paddle, k·u'mEl.
pail (water), ckäm, skwâ'wEs.
pain, ache, sā'im.
my head aches, sā'im tEl sqai'yus.
paint, clā'tlkEls.
paint (to) a picture, &c., Qōē'tsI.
parents, cwä'li.

pass (to), yEhē'ls.
patch, mend (to), pōwē't.
path, trail, kyäktl.
paw, ts'kē'tsis.
pay back (to), what has been borrowed, lau'wilitc.
pay (to), kā'wEtltEl.
peel (to) bark, &c., Hī'pit.
„ „ roots, &c., Hipā'lst.
peep (to) through a hole, tsē'tsEkus.
„ „ from behind a tree, &c., lukwi'lEwil.
penis, ci'la.
people, mistē'ūq, tE m'stē'yūq.
perhaps, yä'swa.
perhaps I'll go, yä'swa, kwa lâm tE elsa.
perish (to), tEkQE'tlsEtl.
pipe-clay, stau'ōk·.
stētauōk· = place where the clay is found.
pitch, gum, kwē'Eq.
plate, lā'tsul.
play (to), āwā'lEm.
I am playing, āwā'lEtcil.
Pleiades (the), s'E'la.
point (to), mā'tEs.
poison (to), kā'iyil.
poison, kā'iyil.
poor, needy, s'tEsa's.
portrait, photograph, Qōē'tsl.
power (physical), skwo'mkwom.
prick (to) once, ts'k·Et.
„ „ repeatedly, ts'k·ts'k·Et.
protect (to), tcā'tlamEt.
proud, smä'tsil.
push (to), HEtsu't.

quarrel, tā'iyuktEl.
quiet (opp. loud), k·wā'k·wEl.
quiet, calm, slē'Ek·wEl.

race, contest, ā'wiltēl.
rain, slEmō'q.
rake, harrow, sqēk·apē'lEp.
raspberry (black), tsilkā'ma.
„ ('red-cap'), t'qum.
„ (salmon-berry), elē'la.
raw, qēts.
recognise (to), pi'tElūq.
I recognise him, pi'tElūq-tcil tō'tla.
red, ckwēm.
red-hot, kwä'itqum.
reject (to), Qoskō'ts.
remember, consider (to), hä'kwilis.
rest (to), kau; take a rest, kau-tcūq.
rest, lie down (to), tlā'kasut.
return (to), k·ä'lsut.
revive (to), sā'wIyEs.
reward (to), kä'wit.
I will reward him, käwit-tcil-tca tōtla.

rib, lū'wEq.
right, good, sEsē'.
ring (a), clä'lumtsis.
ripe, cooked, kwEl.
ripple, yä'tk·um.
lots of ripples, keq yä'tk·um.
river, stā'lō.
roast (to), skwElE'm, kōa'sit.
,, on a wooden gridiron, kE'p'Em.
rob (to), kält.
robber, kE'lkEl.
rod, hā'itcistEl.
roof, sē'kEtsEl.
root, kwo'mloq.
rope, stē'qim.
rose (wild), kälk·.
round, Hilkwā'ls.
rub (to), yEtlk·ut.
rubbish, litter, skE'lEp.
run (to), Qumyä'lEm.

safe, sElä'.
sail (a), pā'tEl.
salt, tlä'tlEm.
salty, tlatlä'tlEm.

N.B.—Although the salt of commerce was unknown to the Tcil'Qē'uk, this is an old Salish term. The word was formerly applied to the peculiar taste of fish when cured in a certain way, that is, by smoking them at intervals instead of continuously. Treated in this way they are said to have a salty flavour. The expression was also applied to the taste of birds when roasted immediately after killing.

same, austEā'.
sand, slē'tsum.
salutation (a), haiyäwEtl = 'may you be well.'
lâmäwEtl = 'god speed.'
The former is used between persons when they meet. The latter is said by your host when you are leaving the house. Your reply is *haiyäwEtl*.
save, heal (to), ä'yElūHt.
say (to), çut.
scald (to), tsä'k·ut.
scald, burn (a), tsäk·.
scalp, kwElEwok = 'head-cap.'
scar, skā'itl.
scold (to), swE'lmut.
scrape (to), ē'EQEt.
scratch (to), Hē'put, qē'k·utsut.
scream (to), kwā't'sum.
search, seek (to), yā'luk·t, sā'wok·.
sea, k·wā'tkwa.
seed, spēls.
see (to), kwatc.

seize (to), tsEklu'met.
sell (to), Qai'Em.
selfish, skwē'Ekwi.
send (to) a person, tcicā't.
send (to) an object, lE'pitc.
sent (thing sent), slE'pitc.
    'send it away,' letlā'm.
sew (to), pā'pEts.
shadow, shade, stā'tEl.
shake (to), QI'cit.
shallow, cā'ik·Em.
shame, qēqalai'His.
shaman, sQElā'm, o'lla, yeu'wa
sharp (of edged tools), ēyä'ts.
sharp (point of pole, pencil, &c.), ēyä'suksEl.
sharpen, grind (to), yu'kust.
sharpen (to), ēyä'ts. This expression differs from the other in that no suggestion as to the manner of sharpening is conveyed. *Yu'kust* means to sharpen by *grinding*.
shave (to) (wood), qI'pEt.
she, her, sEla, sEsä', ço'tla, or sō'tla.
shine (to), klau'Ekum.
shingle (for roofing), sē'kEtsEl.
shoot (to), kwili'H *or* kwili'Ht,
short, tciltcē't.
shout (to), tām.
  „ (a), stām.
shove (to), haukē'lt.
show (to), kwE'tsuq.
shrink (to), kE'lp'sEt.
shrub, QI'QEl.
shut (to), tEka't.
sick, ill, kā'kai.
sight, skwāts.
    my eyesight, tEl skwātkwāts.
silent, tsä'tsauq.
    I will be silent, tsä'tsauq-tcil-tca.
simple, easy (to get), lē'luk.
  „ (to do), kē'ka.
sing (to), stē'lEm.
sink (to), mē'uk·.
sit (to), u'mut.
sit down, u'mut-tla. It is interesting to remark that this same expression, only with the accent on the second syllable, is also employed to bid a person 'get up,' when lying on the bed or ground; thus: umu'ttla, 'get up' or 'sit up.'
skull, tsā'mok .
sky, swā'iyil.
slap (to), tlā'kwut.
slapping, tlā'tlakwut.
slave, skwēi'ts.
sleep (to), ē'tut.
sleepy, ē'tutEm.
slide (to), kē'EqEtsult.
  „ (a), skē'EqEtsult.
slip (to), kē'kEm.
slow, ai'yim.
smart, quick, Qom.
smell (to), hā'kwut.
  „ (a), kā'kwum.
smother (to), kEpā'itsEtEm. This expression is applied also to the tying up of the mouth of a bag or sack,
smile, smā'tsEl.
smoke, spä'tlEm.
snail, kaiä'tlla.
sneeze (to), hä'sEm.
  „ (a), s'hä'sEm.
snore (to), Qē'kwom.
snoring, Qē'EQēkwom.
snow (to), yē'yuk.
  „ syē'yuk, mä'ka.
snow-shoe, tcäliawäHyil.
soak (to), tlE'lkēt.
sock, tcā'QiHyil.
soft (easy to break), Hu'pkum, kē'Eka.
  „ (to the touch), lē'akwom.
sold, Qā'QIum.
solid, s'tEsē'wEl.
sole, cūā'tsecEl.
some, telē'uk·, kwE.
song, stē'lEm.
soon { tE la kais = 'now,' 'this time.'
  au'a hē'tsis = 'not long.'
soot, kwā'itcEp.
sore, blister, kwakwā'tcis.
    'I've blistered my hand,' kwakwā'-tcis-tcil tEl tcälI.
soup, clop.
sour, tä'tEtsum, sä'sEqEm.
sow (to), pēls.
sowing seed, klä'pkEls.
spawn, kElu'q.
sparks (those that fall in white flakes), tEkwā'tsEp.
speak, tell, talk, say (to), skwEl.
spine (of the body), s'q'wālisEwē'ts.
  „ (of a fish), s'q'wā'lis.
spinal cord, kwā'tlEla.
spit (to), sqE'tltca.
  'spit it out,' sqEtl-tla'.
splash (to), slä'lEtem.
splinter, yhE'tsEs.
split (to) (a pole, &c.), suk·Q.
  „ „ (a block, &c.), pē'uk·Q.
  „ or broken object, spEpē'uk·Q.
  'it is split,' spEpē'uk·Q.
spoil (to), kElkē'l.
  'I've spoiled it,' kElkEl(E)-lūq-tcil.
  'he's „ „ kElkEl(E)-lūq-Es.
spoon, ladle (of wood), klI'awEtl.
  „ „ (of horn), qä'lo.
spot, stä'luk.
sprain (to), t'ā.
  'a sprained foot,' t'ā-Hyil.
spring (season), tEm kwēElEs.
sprinkle (to), tlu'ltist.
sprout (to) (from stem of tree), tsē'Em
  „ „ (from root), kwā'kEl.
  „ „ (said of buds), tutlEtsē'lEm.
spruce-tree (Picea), skutlp.
square, stiltilā'kEl.

squeeze (to) (between the hands), pē'tsut.
,, (between the shoulders or body), klē'Ek·ut.
,, (anything that bursts, as eggs, &c.), mō'k·ut.
squint (to), spīpâ'iyilis.
squirt (to), tâ'litsum.
stale, slu'k·äi.
stand (to), tlEHē'liH.
star, kwâ'sil.
stare (to), kwâ'kwâtcitis.
starve (to), Qäls.
steal (to), käl.
steam, spâ'leQEm.
step (to), tâ'tēkilEm.
,, (a), citsitsa'kilEm.
steps, stairs (said when at the top looking down), cū'tlEpEl; when at the bottom looking up, the term is cūkūkwē.
stew (to) ('Irish' fashion), kwelst.
'I stewed this,' tla skwelst· tE elsa, *verbatim* 'this is stew the me.'
stew (a), skwelst.
,, (to) meat, skwElEm.
stick (to), klēk·ut.
sticky, tū'ktūk.
stiff, tsuts.
string, kwiliH = 'to shoot,' has reference to string of the bow.
stink, stench, pe'pitsum, k·E'lEkup.
stir (to), kwē'Ek'lst.
stone, smält.
,, diminutive form, semEle't
stoney, smamä'lt.
stoop (to), kupâ'sEm.
stop (to), klElu'q.
straight, tsuk·.
strange, lâts.
stranger, aui'ta lēs, tEltcak·Q = 'very far off'; the latter term is employed only when the speaker knows the stranger has come from some distant village or place.
strawberry (*Fragaria sp.*), sēya.
strap, muqElmEl.
stray, wander (to), mi'lEmil.
stream, stâ'tElō (dim. of river).
strength, power, cwli'm.
stretch (to), â'tEt.
strike (to) (with stick, &c.), kwâ'kwot.
,, ,, (with hand), tlâ'kwot.
,, ,, (by throwing something), lâ'mit.
stripe (a), skwâkwotōwē'tc.
strong, aiyi'ma.
stumble (to) (over a stick, &c.), tluk·'tlyil.
,, (over stump, root, &c.), tsâ'iukyil.
stump, sk·Ehä'p.
stutter (to), lūksEtcE'tc.
stutterer, ,,
summer, tEm kwâ'lakwEs.

suck (to), k·'mâ'.
suck, darling! k·'mâ'tla ē'yEs! · said by mother to her infant.
sun, slâ'kwum.
sunbeam, swēl *or* swêil.
sunrise, piluk· (tE slâ'kwum).
sunset, tsauq ,, ,,
sure, certain, sEē't, k·äl.
'I'm sure,' k·äl-tcil.
surprise, astonishment, lūwā'tl.
,, (with sense of joy), nEqaiyē'wEl.
swallow (to), mu'kat.
swear (to), kElE'tsil = 'evil mouth.'
sweat (to), ïyâ'kwum.
,, ,, perspiration, sïyâ'kwum (*cf.* slâkwum = sun).
swell (to) (at the stomach), kEtcE'tEm.
,, ,, sQE'tEm.
sweep (to), ēQEtsut.
sweet, k·â'ketEm.
swim (to), tē'tcEm.
swimming, tē'tcitEm.
swift (of running water), lEQō'm.
,, (of animals, &c.), Qō'mQôm.
swing (to), kē'ta.

taciturn, silent, aui'ta skwEltEls.
tail, slEpE'lits, tlEpElatstEl.
take (to), kōt.
he took it, kōtEs.
tale, skwE'lkwEl.
talk, tell, speak, skwEl.
tall, tluktä'mitst.
tame (to), k·wâ'k·wEl.
taste (to), t'ät.
tattler, kwElkwEl.
teach (to), ē'wis.
I will teach you, ōwEs-sā'ma-tcil-tca.
tear (to), Qut.
tearing, QutQu'tEt.
tear (*lacrima*), skâs.
tease (to), hē'ûtsEläk.
tell (to), yi'tsust.
telling, yi'tsEm.
tell (to) a story, kwE'lkwEl.
you tell a story, kwE'lkwEl-tcūq.
tent (of matting), släwelau't, kä'lEmEl.
thank (to), ts'ēt.
that, tE sä' (masc.), sEsä' (fem.) tE lē ti.
thaw, melt, yet.
it's thawing, yet.
he is thawing it, yētEtEs.
melt it! yetE-tcūq!
the, tE (masc.), sE (fem.).
thee, thou, tE lūa.
there, ē'kwē.
they, them, tō'tla-lEm, yEsä', tla'tlEm.
thick, pEtlä't.
thief, kElkEl.
thin, tcimē'l.
think (to), tâlt.

thirst (to), sk·ā'kEla.
this, tE la, tE ē la.
thrash (to), kwā'lEkwāiEtl.
thunder, qōkQā's.
throw, cast (to), lEmi'lstoq.
throw away (to), ē'kwut.
tickle (to), sē'tEm.
tie (to) a knot, kē'sit.
„ up a bundle with string going round it in different directions, sl'ElEtst.
„ up a bundle with string going round the centre only, leqōkwē'wet.
tired, weary, kē'sEl.
to-day, tE la wai'yil *or* wē'yil.
to-morrow, weyili's-tca.
tooth-ache, yilyi'lisEm.
torch (when carried in the hand), slä'kut.
torch (when stationary in house), yē'Ekwēil.
'light the torch' (or lamp), yEkwo'kstla sE yē'Ekwēil.
touch (to), pl'yit.
track (to), ckē'EltEl.
trail, path, kyäktl.
trap (to) (fish), slyā'kEm.
„ (for fish), slyā'k.
„ ('fall,' for animals), tē'tcEl.
„ (pit, for animals), lē'pa.

In digging these they always constructed a V-shaped bottom, so that the animal's legs were forced together, and it was consequently unable to leap out.

„ (noose), Qē'EQakôs.
„ (spring made by bending a sapling), cistEkē'l.
travel (to), lEkä'lEk·El.
tree, skät.
tremble (to), tlä'tq'tEm.
trip (to), tlu'k·ōksEl.
try (to), tät.
I will try, tät-tcil-tca.
tumble (to), tsElk·.
turn (to), said of person, tsā'lisEm.
„ „ said of things, qElst.
twilight, lE tsai'yil *or* tlai'yil.
twist (to) (large things), qElst.
„ „ (small „), qElstē'wut.

ugly, kE'la, kEl.
uncover (to), kwē'Elitct.
under (a thing), sl'pā'lEwEtl.
„ (the ground, deep down), tlup.
understand (to), tâtE'lûq.
undress (to), tlūsä'm.
uneven, rough, smEtlmEtlkwē'lEp.
unfasten, undo (a string, &c.), yu'qwot.
„ „ (a bundle), yu'qwoletst.
„ „ (one's clothes), yuqwolēsum.
unfasten, undo (gate, door, &c.), luqE-yu'qwot.
unripe, au'a kwEl, *ad litt.*, not ripe.
„ qēts.
Ursa Major, k·aiyē'its = 'elk.'

The Tcil'Qē'uk regarded the 'Great Bear' as an elk which wandered round always in the same circle. They told the hour of the night by it.

village, yE-QE'lEmuq.
voice, skwEl.
vomit (to), hai'yut.

wade (to), cē'EqEm.
wait (to), ā'lmitst.
waiting, ā'lmitcEl.
wake (to), QI.
walk (to), ē'miH.
wall, tā'mEl.
wander, stray (to), tcūqtcū'q.
war, qē'luq.
warm, hot, kwä'kwEs.
wart, su'pQEl.
wash (to), sôQät.
watch (to), k·wē'Ek·tlāt.
water, kā.
wave, billow, yā'litca.
we, us, tE tlêmEtl.
weak, k·EkElä'm.
weary, tired, kē'sEl.
weave (to), kai'sitsEl.
wedge, QEHē't.
weed, sku'lEp.
weep (to), qâm.
weir (for fishing), slyä'k·.
when, tEm täm.
when was that made? tEm täm tsē'tEm?
where? ElE'tca?
'where is it'? ElE'tca?
which? tE lEtsa? = the one?
whisper (to), *i.e.*, talk together in low tones, tlā'tlEkEm.
whisper (to) in a person's ear, tlā'kut.
whistle (a), cūcā'kūpEm.
„ (to), cā'pEm.
whistling, yHē'tlpâm.
why? lEtcē'm?
white, pEk·.
who? wät?
wide, stlukä't.
widow, cīā'tEl.
widower, tsē'ya.
wife, stā'lEs; lau, when addressed by her husband.
willow, Qā'ilalp.
win (to), klEQE'luk.
wind, spEhä'ls.
wind (to), k·Elk·ust.
window, skukwātsā'stEl.
wing, stlukä'l.

wink (to), tsētsēkwā'sᴇm.
winter, tᴇm qä'it *or* qä'itla.
wipe (to), ē'akwot.
wise, lukaē'lᴇs.
witch, sorcerer, yeu'wa.
witchcraft, seu'wa.
with, skā.
  I'll go with you, lām-tcil ska tᴇ lūa.
woman, slā'lī.
wood, tsuk·su'k·ᴇt.
wool, yarn (of mountain-goat), sä'ē.

worthless, bad, Qā'auts.
wring (to), p'e'tsᴇt.

yawn (to), wē'wᴇkus.
year, sī'lālᴇm.
yell (to), kwä'tcᴇm.
yellow, skwai.
yes, ė.
yesterday, tcilä'kaçitl.
you, tᴇ tlcwo'p.

An analysis of the above list of words shows many synonyms. Some of these are certainly non-Halkōmē'lᴇm, and are possibly remains of the older Tcil'Qē'uk speech. A comparison of the Tcil'Qē'uk vocabulary with the Kwa'ntlᴇn will illustrate the average or common differences and similarities found in the Halkōmē'lᴇm dialects. The substitution of '*l*' for '*n*' makes the differences seem greater than they really are.

The Pila'tlq.

The Pila'tlq are a small tribe on the lower Chilliwack River, numbering now about five-and-twenty; formerly they were more populous. They border on the Tcil'Qē'uk, the old dividing line of the two tribes lying between the modern white settlements of Sardis and Chilliwack. This tribe was formerly divided into five villages or camps, named respectively *Qwalē'wīa*, *Sqᴇla'utūQ*, *Sk·wä'la*, *Tcūtī'l*, and *Stcā'tcūᴇil*.

The first was so named from a large boulder which lay in the stream close by the village. This rock was once an old woman, a *seūwē'l*, or witch. She was turned into her present shape by Qäls, the Transformer, for venturing to contend with him in magic. Her metamorphosis came about in this way. One day having heard that Qäls was at Yale, pitting his powers against those of a noted shaman there, and was about to come down the river, she urinated in a little receptacle of basketry with the intention of using the liquid to *seuwē'l* (bewitch) Qäls. When they met Qäls derided her attempts to overcome him and turned her into the rock. Said he: 'You are a very poor sort of *seuwē'l*. I can do what I like with you. I will punish you by transforming you into a boulder and placing you in the stream.' This he did, and also the little receptacle she had used; and, placing it on her shoulders, turned it likewise into a stone. Both may be seen there to this day.

The second was so named because of a painted post in the house there, *Sqᴇla'utūQ* meaning the 'painted' or 'marked' house.

The third and fourth were called after sloughs on which the villages were situated.

The fifth was so named because the deceased of this village were always carried down to *Tcūtī'l* to be buried. The term signifies 'a going down.'

I was unable to gather any information from any of them as to their origin. At present they all live together in one settlement, close by the landing at Chilliwack. The name of their present chief is *Qᴇlke'meltuQ* which is derived from qᴇlkt=to 'show,' 'display,' 'mark,' and the synthetic radical for 'house.' They have a tradition of the first white man who came among them about seventy years ago. They call him *Miciyel* and say he was a Hudson's Bay trader.

There were three classes of shamans among the Pila'tlq, viz., the *sQᴇlä'm* or healer, the *seu'wa* or fortune-teller, and the *seuwē'l* or witch.

The functions of the *SQᴇlä'm* among the Pila'tlq do not differ materially from those of the members of his class elsewhere. The *seu'wa* interprets dreams and understands the mysteries of omens and portents generally. The *seuwē'l* is a witch or sorcerer. Members of either sex may fill this office. These individuals are said to use a mystic language of their own. They are paid for their services by gifts of blankets. They are employed to injure an enemy, to hold converse with the dead and with ghosts (poplākwē'tsa). Their methods of working were thus described to me. When a *seuwē'l* wishes to injure someone, he (or she) takes some water at sundown and washes his hands with it, repeating at the same time the name of the person to be harmed. This poor individual will then fall into fits, and black spots will appear on his body. If the feeling of animosity against the victim be very great, he will probably drown or hang himself. Another course is for the *seuwē'l* to secure some garment or other belonging of the person to be attacked and to utter mystic words over it. The *seuwē'l* were commonly employed by the relatives of a deceased person to hold converse with the ghosts of the dead, and to bid them go away and never come back and trouble the survivors again. They were present also at the ceremonial bathing of the relatives and friends of the deceased on the fourth day after burial, and when the mourners were bathing they would go through their ceremonies, such as washing their hands and blowing water from their mouths. They did this to drive away the sickness of the deceased from the village and to send the ghost of the dead to some unfriendly settlement to cause the death of their enemies there.

The *seuwē'l* is by no means an institution of the past among the Pila'tlq, notwithstanding the influence of the priests. The *seuwē'l* still flourishes, and is not infrequently employed at the present time. My informants told me that the services of the *seuwē'l* are invariably employed to protect any of them when brought before a police court for some misdemeanour or other; and to harm the policeman who arrested the person and the magistrate who sentenced him. It is clear from this they yet thoroughly believe in the powers and influence of their *seuwē'l*.

Salmon Myth.

Very long time ago there were no salmon in the river except the 'steel-head' (kēū'q).[1] So one day S'kᴇlau' said to the people, 'Let us leave this country and go for a trip down the river.' *Tsē'uk·t* (woodpecker), *T'sc'kel* (bird not identified), and *S'mātq* ('bull-head' fish) agreed, and the four started off together. They went down the river, and in course of time came to a village. It was night. 'Said S'kᴇlau': 'Look at the smoke: it has all the colours of the rainbow. This is where the Salmon people live. Now I am going to steal the chief's baby and carry him off, and then we shall get lots of salmon.' So he presently crept towards the settlement, taking *Kwā'tel* (mouse)[2] with him. S'kᴇlau' threw himself down in the pathway on his back and feigned to be dead. *Kwā'tel* made his way to the canoes and gnawed holes in them, and also knawed the paddles in such a manner that a slight strain upon them would cause them to break in two. Besides the Salmon people a *Kaia'tlīa* (snail) dwelt in this village.

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[1] The *kēū'q* is not a true salmon, but a species of trout, *Salmo Gairdneri*.

[2] After the manner of Indian myths the mouse here appears from nowhere, and after its task is completed disappears in like manner.

At daybreak one of the women left the house to get some water, and as she went to the stream she came upon Beaver lying upon his back in the path apparently dead. She had never seen anything of the kind before, and became alarmed, and cried out to the others to come and see the *Cla'lakum* (spirit, supernatural being). They all rushed down to see the strange thing. No one knew what it was, and all expressed surprise and fear, the more timid bidding the rasher not to go too close. As they stood gazing and wondering, one ran down from the village and pushed the crowd aside, saying, 'Let me see him ; I think I know that person.' This was *Kēū'q*, the 'steel-head' salmon ; who, when he saw the Beaver, said : 'I have met this person before in my visits up the river. You must be careful of him, he is a very crafty fellow. Give me a knife and I will cut him open, and you shall see what he has in his mind ; he is here for no good purpose.' As he was about to cut Beaver open *Tsē'uk·t* and *Tsc'kel* came flying over their heads, making a great noise and attracting everybody's attention. They all left Beaver and endeavoured to catch the birds. The latter pretended to be lame and enticed the people to follow them. While everybody was trying to secure the strange birds S'kᴇlau' opened his eyes and looked about him. Seeing all the people preoccupied with his friends, he quickly made his way to the house. Inside he saw a baby hanging from the swing-pole. In a moment he snatched it down, and making straight for the river plunged in and carried it off. *Tsē'uk·t*, who had been watching him, now called out to *Tsc'kel* to make for the canoe. When they got there they found Beaver waiting for them with the baby in his possession. They instantly paddled off. The Salmon people then rushed for their canoes and gave chase to them. But no sooner did the paddlers bend to their work than the paddles snapped one after another. The water, too, forced its way through the holes in the canoes made by *Kwā'tel*, so that they could make but poor headway. A few of them, however, whose canoes and paddles Mouse had overlooked, did better, and steadily gained upon the fugitives, who were stupidly paddling with the edge instead of the flat of the paddle. Presently they passed by a point where *Kaia'tlīa* (the snail) was standing watching the chase. Seeing them paddling with the edge of their paddles she cried out : 'Paddle with the flat of your paddles and you'll get along faster.' They followed *Kaia'tlīa's* advice and soon gained upon their pursuers, who, seeing they were losing ground, presently threw their paddles aside, jumped into the water, and began to swim after them. When S'kᴇlau' and his friends got up the Fraser as far as the Coquitlum River they took off the baby's *skilatl* (under-garments). One of these, a dirty one, they threw into this stream. Hence they went on to the Chilliwack River, and into this they cast another *skilatl*, this time a clean one. They went on to the Harrison River and dropped another there, and thence to Yale, on the Fraser, where there was a *tsīā'kq* (fish-weir). On the lower side of this they dropped the child ; whereupon the water began to rage and boil. The four adventurers now separated and went up different creeks and became *sla'lakum* (supernatural beings).

From this time onwards the salmon have visited annually the streams mentioned ; but because the dirty *skilatl* was thrown into the Cōquitlum the salmon taken in that river are bad and difficult to dry. At the Harrison something kills the salmon, and they die in great numbers there. In the Chilliwack, on the contrary, they are good and fine, and are easily dried and cured.

There are many points in this story which recall the manner in which

S'kᴇlau' secured fire for the up-river Indians. Shamming death in this manner is evidently a common subterfuge of S'kᴇlau'. In the N'tlaka'pamuq story his assistant was the eagle.[1]

The Origin of the Totem of the Sqoi'aqi[2] *and* Cilmu'qtcis *as told by the Pila'tlq.*

There once lived a young man who was afflicted with *sk·ōm* (leprosy). He was very ill, and cried all the time. So burdensome was existence to him that he determined to end his life. So he went to a lake which was inhabited by 'Sla'lakum' (a kind of water-sprite) with the intention of drowning himself. Two creeks led out of this lake. Up one of these he went, and as he did so he perceived a *kō'kūaç* (salmon, 'sockeye'). Thereupon he cut a stick, and having pointed it speared the salmon with it. He then made a fire and roasted the fish, with the intention of eating it. When cooked he laid it on some leaves and sat contemplating it for some moments. Presently his attention was drawn away from the salmon, and when he looked again, in place of the fish he perceived a *pipahä'm* (frog). He turned away in disgust and proceeded up the creek to the lake. When he arrived there he undressed himself on a projecting rock and jumped into the lake. He sank down and lost consciousness. After a while he came to himself again, and was greatly surprised to find that he was lying on the rock from which he had a little time before plunged into the water. 'Why cannot I die?' he cried, and shed many tears again. Presently he determined to cast himself in again. He took the plunge, and felt himself sinking down into the depths of the lake without loss of consciousness. Down deeper and deeper he went, and presently he found himself lying on the roof of a house. This was the habitation of the lake people, who were startled by his fall on their roof, and sent one of their number up to see what was there. He perceived the young man and reported that a 'Sla'lakum'[3] was there. He was then brought down and treated with great hospitality. The Sīa'm gave him his daughter to wife. She and others among them were sick. This sickness had been caused by himself. He had spat in the lake, and his tears had also fallen into the water. This had caused a sickness to fall upon some of the lake people. It was always thus. If any of the earth people spat in the water it caused sickness among those who lived below. He wiped off the spittle from the girl and she was straightway cured. He healed the others in like manner. While among the water people he saw the *Sqoi'aqī* and the *Cilmu'qtcis* for the first time.

In the meantime his parents and the rest of the family had gone up the river towards Yale to catch and dry salmon. In this lake of the Sla'lakum lived the *Kō'kūaç* and the *Skᴇla'u*, who wanted to get out into the Fraser. So they dug and dug, till at last they came up through a hole near Yale. The youth, who had watched and followed them, also came up at the same place and floated about on the water. It was death to any person now to look upon him unless healed by himself. Not far from where he was his parents and sister were fishing. The latter presently came by, saw him, and straightway fell sick. He then left the water and went to her and healed her. They then went home together. When his parents saw him they too fell sick, but he healed them also. And so it was with all who came in contact with him. All fell sick because he was *sla'lakum*, for whoever looked upon a being of this kind became sick unto death. He healed them all so that no one died because of him. Shortly after he sent his sister to the lake to fish, and bade her use feathers for bait, and not to be frightened at anything she heard or saw. She did as he bade her and threw in her line, and presently felt that the bait had been seized. She drew in the line, and the water people came up to the surface wearing the *sqoi'aqī* and using the rattle. They danced for a while, and then presented her with the *sqoi'aqī* and *cilmu'qtcis*. After this they descended again, and she went home with her gifts. Her mother then made a *sköäm* (big basket) in which the girl put away her presents. At her marriage she was given the *sqoi'aqī* and rattle.

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[1] See the writer's notes on the N'tlaka'pamuq, Third Report of the Committee, 1899.

[2] The Sqoi'aqī is a strange-looking mask with feathered head and staring eyes, and the Cilmu'qtcis is a rattle made from the hoofs of the deer. This totem plays an important part in the ceremonies and customs of the Halkōmē'lᴇm tribes.

[3] It would appear from this that mortals were *sla'lakum* to the water beings as much as the latter were to the earth people. This term *sla'lakum* is difficult of direct translation into English. A sla'lakum is not a ghost or spirit, but a being of a different order from a mortal. They inhabit mountains and forests as well as lakes. Their analogue is found amongst most peoples at some stage of their culture.

This incident is said to have happened at the village of *Tlĭ̧eltä'litc*, a little above Hope. It is noteworthy, however, that somewhat different origins are given by other tribes to the *Sqoi'aqī* and *Cilmu'qtcis*.

Mortuary Customs.

As the Pila'tlq have been under missionary influences for a number of years most of their old customs have been given up or much modified. In burying their dead they now wholly adhere to the customs of their white neighbours, but formerly they disposed of them in the following manner. Immediately upon the breath leaving the body the *spolākwe'tsa* (corpse) was carried out of the house and washed in warm or cold water. Usually four men performed this task, and while they were engaged in their work, if the deceased or his relatives were people of rank and wealth, the *sqoi'aqī* would be hired to dance the *ts'qāte'l*, or 'wash-down dance.' After the corpse had been washed it was painted red; the hair was then smeared with grease, and a quantity of eagle-down was spread upon it. The body was then doubled up and wrapped in blankets, and the *sqoi'aqī* performed another dance. After this it was conveyed to the burial grounds and deposited in the family coffin. This receptacle was a large box capable of holding the remains of several persons. In the case of chiefs or wealthy persons figures of animals or birds were carved upon it. After the *spolākwē'tsa* was laid away the *sqoi'aqī* gave another dance and the mourning began, and the funeral party returned to the village. Four days later all the mourners took a bath, and a feast was then held if the relatives of the deceased were people of rank and wealth, and many presents were distributed. Everyone received something. Nothing of the dead man's personal belonging was kept, and if the presents were not enough to go round among those assembled his brother or other relatives supplied what was needed. The object of disposing of everything that belonged to the deceased, I was informed, was that the survivors should not be reminded of their loss by the sight of them. Occasionally a wife mourning the death of her husband would set aside and store away some garment belonging to him, and in after years, when she had amassed much property, she would hold a great feast and give it all away. During the feast she would bring this garment out and display it to her guests, and dwell in a mournful strain upon the many virtues of her late husband. Her words usually stirred the feelings of others of the relatives of the deceased, and they were moved to do likewise, and much property was again given away. These gifts were made outright: they were not 'potlatched,' and no obligation rested upon the recipients to make any return. Though when some connection of theirs passed away, and they gave a burial feast, they specially remembered those who had been generous to them under similar circumstances, and treated them in like manner.

The name of the deceased must not be mentioned in the hearing of the surviving relatives till some years have elapsed, when his son gives a feast and assumes it. During the feast the oldest man present gets up and publicly states that their host is desirous of assuming his father's name. Those present acquiesce in this desire, and the son is known henceforward by the name his father bore. The reason of this lapse of time between the father's death and the son's assumption of his name or title is due to their conception of the state of the soul or spirit after death. The *poplākōe'tsa* (ghost) of the dead is supposed to haunt the scenes of its life for a longer or shorter time, and if the son assumed the name too soon the *poplākōe'tsa* of his father might exercise a baneful influence upon him. Hence the delay.

All the mourners cut their hair and burn the severed parts. They did not cut the hair all round their heads, but only that on the forehead and temples as far back as the ears. Those who tended the corpse were apparently a distinct order or class. They could not mingle with the rest for a time. They had first to undergo some kind of purification. They were called *spoplākōē'tsa*, that is, 'corpse handlers.' When they had finished with the corpse the *sqᴇlä'm* took charge of it and conveyed it to the tomb.

The Kwa'ntlᴇn.

In my studies of the Kwa'ntlᴇn I was assisted by a native named August Sq'tctᴇn, of the Fort Langley Reservation, an intelligent and thoughtful Indian, who had been trained in his younger days in the mission school of the Oblate Fathers, and who had a very tolerable knowledge of English; by Jason Allard, a fairly educated half-breed; and to a less extent by an elderly Indian woman named Mrs. Elkins, the wife of a white fisherman of the district. If my studies of this tribe could have been begun a few years earlier I could have secured much valuable information now, I fear, lost for ever. A noted old shaman among them, who is reported by the natives and white settlers to have been able to do many strange and mysterious things, such as dancing on hot stones, handling live coals, and drinking or otherwise mysteriously disposing of enormous quantities of liquids, such as oils or water, died a year or two ago, and with him passed away the opportunity of acquiring first-hand information on many of their old customs, practices, and beliefs, thus affording another illustration of the need there is to push our inquiries and observations without further loss of time. Most, if not all, of the present Kwa'ntlᴇn have been born since the settlement of the Hudson's Bay post in their midst, and their early contact with the white men connected with this and their long training by the Fathers of the Oblate Mission have much modified and changed their habits and lives. The whole tribe is now under the religious care of this mission, and all the present Kwa'ntlEn are converts to the Roman faith, few, if any, of them holding the old beliefs or practising the old customs of the tribe, which are now practically traditions only among the present members. Consequently I was unable to get such full or detailed accounts of the past among them as among some of those who came later under white or missionary influence.

Ethnography.

The Kwa'ntlEn were formerly one of the most powerful and extensive of the river Halkōmē'lEm tribes. Their territories extended from the mouth of the south arm of the Fraser up to the present settlement of Hatzic, which is about sixty miles from salt water. They consequently occupied or controlled more than half of the Halkōmē'lEm lands of the mainland. They touched the *Qmuskī'Em* of the north arm, and the *SEwā'çEn* on the sound on their west; the *Ke'tsī* on Pitt River, a tributary of the Fraser, which enters the river a little above New Westminster; the *Snonkwe'amEtl*, of the Indian village of *Snā'kwamEtl*, a tribe now wholly extinct and well-nigh forgotten; the *Maç'quī*, whom they drove back from the river front, in their centre; and the *NEkā'mEn* on their east. Their occupation of the upper part of this territory dates only from the founding of Fort Langley by the Hudson's Bay Company. Prior to this they were mainly settled at or near what is now the city of New Westminster. Adjacent to this old settlement was the limited territory of the Kwī'kwitlEm tribe, who are said to have formerly occupied these lands. They were a subject tribe held in servitude by the Kwa'ntlEn, who treated them as their slaves and servants. According to one Kwa'ntlEn tradition, they were brought into being for this purpose. Historically considered, they are probably a non-Halkōmē'lEm people and the predecessors of the Kwa'ntlEn in that portion of the delta. They number but a few souls now, and their long association and later intermarriages with the Kwa'ntlEn have apparently effectually effaced any ethnic differences they might once have exhibited. Archæological investigations show occupation and settlement of the old centre of the Kwa'ntlEn people centuries, or perhaps millenniums, before the Halkōmē'lEn tribes could have arrived on the river.

The present village settlements of the Kwa'ntlEn, as enumerated by my informants, are as follows, the order being from east to west down the river:—

Sqai'Ets, on Stave River.

Hō'nak, a division a few miles below the mouth of the Stave River, which has given the name 'Whonnoch' to the white settlement and railway station of that vicinity.

Kwa'ntlEn, at Fort Langley.

Sqai'amEtl, at New Westminster.

Kīkait, at Brownsville, on the opposite side of the river.

The Kwa'ntlEn have always regarded themselves as the head of the tribe, the *sīā'm* of this division being always the supreme chief of the whole tribe. I could not obtain the original signification of the term Kwa'ntlEn. Formerly they used to call themselves *tE sīā'm-Kwa'ntlEn*, 'the royal Kwa'ntlEn,' or 'the Kwa'ntlEn-royal.' They were undoubtedly once a numerous and powerful tribe, and are known to have kept undisputed control of the river from its southern mouth to the borders of the *NEkā'mEn*, sixty or seventy miles inland.

Of their origin they give various mythical accounts. Among the Kwa'ntlEn proper the first man was called Swā'nisEt, meaning 'to appear or come in a mysterious manner. He was a *tEn Swē'yil*, 'descendant of the sky,' who suddenly appeared on the Fraser River. Another account makes the first man a *tEn T'E'muH*, a descendant of the earth. This latter is possibly an adaptation of the Mosaic account of the first man. With him were created all the native tools and utensils, and also the *Kwī'kwitlEm* tribe to be his slaves. His name is given as *Sk·wElsē'lEm*. The sīä'm-Kwa'ntlEn have a genealogical record of their chiefs for nine generations. It is as follows ;—

1. Sk·wElsē'lEm I.
2. Sk·wElsē'lEm II.
3. Sk·wElsē'lEm III.
4. Ctla'lsitEt, afterwards changed to Sk·wElsē'lEm IV.
5. Sq'tctEn I. Sk·wElsē'lEm IV. dying without male issue the sīä'm-ship passed to his sister's son ; hence the change of name.
6. Sq'tctEn II., afterwards changed to *Stltī'mtEn*, which has reference to thunder. The story in connection with the change of name was forgotten. The name is a *su'līa* name.
7. Sq'tctEn III.
8. Sq'tctEn IV.
9. Sq'tctEn V., who is the present chief.

The original signification of these names seems to be forgotten.

In the lives of the earlier chiefs certain important events are recorded as happening. Thus, when Sk·wElsē'lEm II. was chief a mighty conflagration spread all over the whole earth, from which but few people and animals escaped. This would seem to refer to some volcanic phenomena in the experience of their ancestors. During the lifetime of Sk·wElsē'lEm III. a great flood overwhelmed the people and scattered the tribes. Then it was, according to the Kwa'ntlEn belief, that the Nootsak tribe was parted from the Sk·qō'mic, to whom they are regarded as belonging. They also say that a branch of the Kwa'ntlEn named *Pe'lqeli* settled on the coast somewhere opposite Alert Bay, and they assert that this tribe still lives there and speaks the Kwa'ntlEn language. If there is any truth in this statement they have not yet been made known to ethnologists. When the statement was first made to me I very naturally concluded that I was getting an account of the settlement of the Bilqula tribe, but when I mentioned them they assured me the Pe'lqeli were not the Bilqula, but a distinct tribe, speaking the Kwa'ntlEn tongue, which lived beyond the Bilqula territories. I have thus far not yet been able to test the truth of this statement. It certainly will be an interesting fact if the Pe'lqeli can be found and identified as Kwa'ntlEn.[1]

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[1] From further inquiries since the above was written I am disposed to think this tradition *does* refer to the Bilqula tribe. It will be seen that *Pelqeli* is merely a dialectic variation of *Bilqula*. In speaking with the Kwa'ntlEn of this tribe I always used the English form *Bella Coola*. This doubtless misled my informants. Moreover, it is worthy of note that the Bilqula themselves have a tradition connecting them or their ancestors with the Fraser River region. In the important myth of *Tōtosō'nq* the Fraser River is given as the place of his origin. The term *Pelqeli* also occurs in Bilqula legends under the form Pelkhany or PElqanī. It is the name of a

When Sk·wᴇlsē'lᴇm IV. was living a severe and prolonged famine decimated the tribe. This famine was caused by a great snowstorm of unusual duration. It lasted for many weeks. It may be incidentally remarked here that the Sk·qō'mic have similar traditions of a devastating flood and a destroying famine caused by a prolonged snowstorm.[1] It was during the siā'm-ship of Sk·wᴇlsē'lem that the Kwi'kwitlᴇm were sent away from their very desirable camp on the slopes of the hill upon which the city of New Westminster is built to the marshy flats opposite, across the river. These they were compelled by the Kwa'ntlᴇn to fill in with stones and gravel and convert into fishing grounds for them.

Sociology.

The social organisation of the Kwa'ntlᴇn in pre-trading days seems to have been much the same as that of the contiguous Salish tribes. They had the common threefold division of the tribe into chiefs, notables, and common folk. They lived in the communal long-house, but their meals do not appear to have been of the communistic order, as among the Tcil'qē'uk. It is clear from the genealogical lists of their chiefs that the office of siä'm was practically hereditary among them.

In their marriage customs they appear to have departed in some respects from the customs usual among the river and coast Salish. Among them the choice of a wife or a husband was never left to the son or daughter, but was always made by the parents themselves. When a young man's future wife had been chosen for him by his parents he would, after the manner of the Sk·qō'mic youth, go to the house or apartment of the girl's parents and squat down near the entrance for a longer or shorter time. But the Kwa'ntlᴇn suitor never stayed at night. He always returned to his own home at nightfall. If he were a youth of rank he would not be kept waiting long by the girl's parents. Sons of poor parents had sometimes to wait many days before they were accepted by the girl's relatives. When the suitor was acceptable, and his period of waiting was over, the father of the girl would call together the elders of the tribe, and desire them to select from among themselves an intermediary to acquaint the youth of his success and lead him to the girl. The suitor must reward this old man with gifts of blankets. He must also now make presents of blankets to the girl's father. After this the father of the youth calls his friends together, and they all go to the house of the girl's father and present him with blankets. This ceremony was called *sī'ᴇçältūq*. When this ceremony had been performed, the father of the bride, if he were a wealthy man and a person of rank, hired the sqoi'aqī to precede his daughter as she walked from the house to the canoe to go to her husband's home. The father of the youth, if he had a good store of venison on hand, now gave a feast. If his stock of provisions were short, he hired some of the skilled hunters of the tribe to procure fresh game and fish for him. These he took to the house of the bride's parents, and they held a feast there. This concluded the marriage ceremony.

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certain chief in their mythology who possessed a house decorated with Abelone shells, the term, according to Dr. Boas, meaning 'Abelone.' Among the Kwa'ntlᴇn the signification of Pelqeli is forgotten.

[1] See the writer's Notes on the Cosmogony and History of the Squamish Indians of British Columbia, *Trans. Roy. Soc. Can.*, vol. iii., sect. ii., 1897–98.

Originally the Kwa'ntlᴇn were endogamous. They would not sully their 'royal blood' by marrying among the neighbouring tribes, whom they regarded as inferior to themselves. This is a fact of importance in the consideration of the social customs and institutions of the tribe. I was unable to discover anything like a developed totemic system among them. As among the Tcil'qē'uk, it was customary for everyone to seek personal *su'lïa*. They had both personal and family crests, the most important of which was the sqoi'aqī already described. The owners of this crest or totem, or those entitled to its privileges and the use of its strange emblems, were much-envied people. One or more members of this totem were hired by wealthy people on special festive and ceremonial occasions to be present and lend their powerful and propitious influence to the event, as many, sometimes, as 300 of them being present at the name-giving feast of a chief's son. According to my informants, among the Kwa'ntlᴇn the sqoi'aqī was not a secret society. Its membership was recruited and augmented by marriage only. It will be remembered that the crest or emblems were first obtained by a woman, and by her marriage, and the marriages of her descendants, spread among the river tribes. Most tribes on the river contained one or more individuals entitled to use the sqoi'aqī emblems. When we consider for a moment the social importance the possession of a crest or family totem, such as the sqoi'aqı, gave to its owners, we can well understand how personal and family crests develop sooner or later into gentile totems. Had the social organisation of the Halkōmē'lᴇm tribes not been interrupted in its development by the advent of the whites, it is more than probable that in a few generations it would have reached a fully developed totemic system of its own; and that, too, without extraneous aid or suggestion. The sqoi'aqī had its origin, some generations ago, among an up-river tribe whose members probably were entirely ignorant of the social organisation of the northern coast tribes, with their totemic systems and secret societies. It would appear to be the natural outcome of primitive organisations where the fetish has passed into the su'lïa, and these, again, have given rise to the personal and family crest, or totem, as among the river tribes. Among all the tribes of this region the desire for social distinction is the predominating impulse of their lives; and as personal su'lïa and other totemic emblems of striking character or appearance bestow social importance upon their owners, it is but natural to expect to see these totemic emblems and crests spread and increase. The tendency to do so is inherent in such social bodies. The social privileges and distinctions accorded to the owner of a potent and striking totem like the sqoi'aqī by his fellow-tribesmen would assuredly create a desire on the part of those who did not possess or share in the privileges of such crest to possess similar ones for themselves; and this desire would lead the bolder, and more imaginative, to acquire similar crests or totems for themselves. The origin of the sqoi'aqī itself is an instance of this. The wholesale acquisition of su'lïa or crests of this kind was restrained and held in check only by that fear and dread of the 'mysteries' entertained by the majority of Indians. Out of this restraining fear and from this selfsame desire grew the secret societies of the coast Salish and Kwakiutl tribes, where, by the payment of large initiation fees and the performance of certain esoteric ceremonies, the man of social aspirations could obtain admittance into and a share of the social privileges of such societies. Dr. Boas has shown that in some tribes a man's social position and distinction depended entirely upon his membership in one or more of these societies. Unless he were a member of some society he was little better than a slave ; he possessed no social status whatever. The social organisation of the river Halkōmē'lᴇm tribes had not reached to the secret society stage, though it was clearly on the point of doing so when its course was interrupted by our advent. It was just at the point where the personal and family totem passes into the gentile totem, and brotherhoods and privileged societies arise. The totem of the sqoi'aqī makes this quite clear.

When the totemism of this coast is viewed in the light thrown upon it by a study of the tribal organisations of the different Salish tribes, it ceases to appear strange that it differs in some characteristic features from totemism as found elsewhere. The totem arising here out of a mythic adventure—in other words, out of the imagination of its owner, or that of his ancestors, or from individual su'līa acquired in dreams or visions—it is not surprising that our Indians do not regard themselves as descended from the prototypes of their totems. And when it is remembered that they all believed that animals and many other natural objects were only transformed men and women, and that the relation between these and themselves was of an intimate nature, the significance of this feature becomes the greater. If their totems had not been evolved from their earlier su'līa, nothing would have been more natural than for them to regard themselves as descended from their totem prototypes. But they do not ; and in this all competent observers agree. It may be that among those peoples that regard themselves as related to, or descended from, their totem prototypes nothing equivalent to su'līaism existed. Without this intermediate stage it is possible, as many primitive races look upon animals as only transformed human beings, that the totem possessor regards himself as related to it by descent. Personally, my experience does not extend to such races, and I have no knowledge of such concepts ; but I can well understand, knowing, as I do, the extreme difficulty of getting at the inner thoughts, beliefs, and conceptions of races on different planes of culture from our own, that a hasty or superficial observer would conclude that our Indians believed themselves to be descended from their totem prototypes. Indeed, I have seen and heard it so asserted. It is clear, therefore, that the totemic question is one requiring great care, much patience, and an open mind for its study.

I have said of the Tcil'ǫē'uk siä'm that he was also the tribal high-priest. Among the Kwa'ntlᴇn he was pre-eminently so. No religious ceremony or observance could be carried on without his officiating presence. His religious functions must not be confounded with those of the sǫᴇlä'm. They were quite apart and different from those of the shamans. On the occasion of any public calamity, such as a widespread sickness, times of famine and want, during meteorological disturbances or abnormal celestial and terrestrial phenomena, such as violent storms, prolonged droughts, earthquakes, and eclipses, he it was who led and conducted the prayers and confessions of the people and invoked the pity of *tᴇ tcītcil siä'm*, or 'the Sky chief,' whom he addressed as *Cwai'ᴇtsᴇn*, i.e., 'parent,' or 'Father,' or 'Creator.' He would bid the people come together on these occasions and pray and dance ; the latter action being regarded as propitiating and honouring in their estimation. As they danced the people would hold their hands aloft. At the close the chief would bid them place them on their breasts and repent of their evil deeds and thoughts.[1] I obtained one of their *s'ē'mi'n* or prayers in the original Kwa'ntlᴇn, which was used during times of earthquake or eclipse. It is as follows :—'O sīä'm Cwai'ᴇtsᴇn so'qmis-tōq, nᴇtcīmā' ᴇs-mē sē'sō ī tᴇ-nā' tᴇ'mᴇʜ ? Nᴇ-stlē kwᴇns ī tᴇ-nā' ᴇs-yā'ēs-etl tᴇ'mᴇʜ.' Translated into English it runs thus : 'O supreme Father, have-pity-on-me. Wherefore hast-thou-brought me here on this earth ? I desire to live here on this earth (which) thou hast made for me.'

Of the Feasts of First-Fruits, the Kwa'ntlᴇn, according to my informants, observed only the Feast of Salmon. This was celebrated after the salmon had been running three days. A salmon would then be caught, and brought reverently on the arms of the fisherman (who must not touch the fish with his hands), and given to the sīä'm, who then uttered a s'ē'min over it, after which it was cooked and a morsel of it given to each member of the tribe. The ceremony throughout was conducted much as described by me in my Report on the Lower N'tlaka'pamuq.

Dances.

Besides the religious dances, in which all the people joined, there were the social, totemic or su'līa, and shamanistic dances. These were divided into two classes, each called by a special distinguishing term, viz., *smē'tla* and *skwaiē'liʜ*. The former were the 'dream' or su'līa dances, the latter the common social and religious dances. Of the smē'tla[2] dances the Kwa'ntlᴇn had apparently a great number. I secured the names and some account of some eight of these. They are as follows :—

1. *Sīwā'nok*, or 'war dance.'—This was exclusively a warriors' dance. It was of slow and stately movement, and was always performed on the eve of a fight. Sometimes it appears to have been performed during the winter festivities as well, the winter season being pre-eminently the period of dancing and social gatherings of all kinds.

2. *Sīā'tlnuk.*—The characteristic feature of this dance was the burning of food and grease in the fire by the performer. He also scattered much down over the fire. I could not learn the significance of these acts. The movements of the dance were rapid.

3. *Skā'kwᴇtl.*—This was similar to the last, only the movements of the dancer were in this case slow and solemn. Notwithstanding this the dancer always steamed and sweated in a copious manner.

4. *Snu'kwīmᴇtl.*—This was *par excellence* a 'sweat' dance. It was likewise of slow and gentle movement. The owner of this dance had seen his 'familiar,' the *snu'kwīmᴇtl*, sweating in his dance in his dream ; hence he himself always sweated prodigiously whenever he performed his su'līa dance. He must dance with a soft and gentle tread ; for if he struck the ground hard it was believed he would soon die.

5. *Tlaçukē'lᴇm* = 'cold' dance.—Whenever the owner of the su'līa of this name performed his dance he shivered violently with cold. His 'familiar,' *Tlaçukēlᴇm*, a kind of ice-bird, was supposed to have had his

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[1] This savours suspiciously of later Roman teaching, though it may be genuinely Kwa'ntlᴇn or Halkōmē'lᴇn in its origin and practice.

[2] Dr. F. Boas makes this term a borrowed one, and regards it as of Kwakiutl origin. It is so universal among the river tribes that I am disposed to think that view needs reconsideration. As far as its form goes it is as truly Salish as Kwakiutl, indeed more so, having here the prefixed *s*, which converts the verb into a verbal noun—a characteristic strikingly Salish.

abode in the Arctic or northern regions; hence the shiverings. The movements of this dance were active to a degree. I call attention to the condition or state of the dancers in these last three dances—the two with gentle and slow movements always steamed and sweated prodigiously, the last, with violent and active movements, shivering violently and visibly with cold. These were the characteristic features of the dances. They afford examples, I think, of the power which the mind or imagination of these dancers exercised over their bodies. Their condition, provided it was genuine—and I see no reason to doubt it—can only be explained by auto-suggestion or hypnosis. The psychological aspects of these and other shamanistic practices and performances deserve more attention and study than have hitherto been accorded them.

6. *Sqoi'aqī.*—This was the dance belonging to the totem of this name. Its members performed it on most festive and ceremonial occasions. Generally they were hired for the purpose. The sqoi'aqī figured largely in the naming-feasts of chief's and other notable men's sons.

7. *Skai'ᴇp* = 'blood' dance.—The performers in this dance cut and scarified themselves with stone knives till the blood ran from them. Blood was said to ooze from their mouths. At the conclusion of the dance they would rub their hands over their blood-besmeared bodies, and all trace of it was said to disappear. This is a dance common to most, if not all, of the river and coast Salish. The spectacle of the dancer devouring a live dog, or tearing it piecemeal with his teeth, was also a feature of this dance.

8. *Taiwᴇltä'lᴇm*, 'fire' dance.—This was pre-eminently a shamanistic dance. The performer in this would handle fire, place hot coals in his mouth, and dance upon hot stones. It is, of course, difficult now to ascertain, with any degree of certainty, how far these performances were genuine. Eye-witnesses of them, both native and white, are unanimous in declaring that these fire-shamans could handle fire and burning objects and dance upon scorching hot stones without apparently burning or otherwise harming themselves. The late Bishop Durieu, who spent over forty years among the Indians of this district, once told me himself, in a conversation on this subject, that he had seen a shaman handle burning brands without apparent hurt to his hands. He said he had been preaching to the tribe of the power of the Christian's God, and had observed an Indian squatting apart by himself in a far corner of the house. When he had finished his discourse this man came forward, and made some remarks to the effect that it was all very well to talk, but the proof of the pudding was in the eating. Could the white medicine-man give them an example of his 'power'? and he thereupon challenged the Bishop to a contest with himself. Said the Bishop: 'He seized from the midst of the fire, in his naked hand, a fiery burning brand, and held it there for some time, and then offered it to me. I declined, and was straightway scoffed at by him and his friends; but eventually I turned the tables upon him by declaring that his power came from the Wicked One, with whom I could have no dealings, and not from the true God.' The Bishop's long experience with the native shamans, and his observations of their undoubted supernormal powers, led him to the conviction that they were assisted, after the manner of the witch of Endor, by 'familiar spirits.' However one may explain such cases, the fact of their possessing these powers is witnessed to by most credible and intelligent observers. The common view of these performances is that all are tricks, sleights of hand, or

deceptions of some kind, and nothing more. Those familiar with the results of the investigations of the Society for Psychical Research into these and kindred phenomena will not be disposed to dismiss these accounts in so convenient and offhand a manner. That much of the performances of the old shamans was pure humbug I do not myself for a moment doubt; but I cannot bring myself to believe that all falls under this head. In the case of the fire-handlers—and it must be remembered only a few shamans possessed the power to do this—their immunity from harm may be, and very probably is, due to some psychic condition, such as auto-hypnosis. Hypnotism, as I pointed out in my remarks on the Sk·qō'mic dancers in the last Report, plays an important *rôle* in shamanistic performances. Another strange power in the case of some of these shamans is their seeming ability to drink, or otherwise mysteriously dispose of, large quantities of liquids, such as water and oils, which have been used in shamanistic rites. Jason Allard, one of my informants on the Kwa'ntlᴇn, a half-breed of considerable education and of superior intelligence, and in no way disposed to be credulous in such matters, told me incidentally that he had seen the last sqᴇnä'm of the Kwa'ntlᴇn drink a large milk-pan full of oil, which he had used upon a sick girl. His surprise at the man's feat caused him to ask how he could take so much nauseous liquid into his stomach. The reply he got was: 'I didn't drink it; my *su'līa* took it away.' Others of that district, both white men and natives, have assured me that they had seen the same man drink down two and three buckets of water successively, each bucket holding between two and three gallons, and when they looked to see him swell up his appearance was quite natural. He would perform this feat in the house before them all, in their midst, where he had no opportunity of disposing of the water in any other way than by drinking it. Before exhibiting his powers in this way he would always go through his 'dream' dance; and after his feats he would lie down in a trance state for some time.

In explanation of these feats it may be that the long fasts and protracted visions and trances the shamanistic novice undergoes in his search for his 'familiar spirit' may give him certain hypnotic or other supernormal powers not possessed or understood by the ordinary individual. Those familiar with the extraordinary phenomena of experimental hypnotism will have no difficulty in understanding this. At any rate, however these shamanistic feats are explained, they are worthy of careful study and investigation. It is not enough to put them aside with the assertion that it is all humbug, ignorant superstition, or crass credulity.

All dancing was accompanied by singing. Each performer had his or her own dance-song, called *seuwᴇ'n*, in contradistinction to the ordinary song or *stī'lᴇm*. As a rule the performers in the *smē'tla* dances always danced singly, one at a time. It would appear, also, that all of them wore a special kind of headgear for the occasion; not masks, but a kind of cap.

The shamans among the Kwa'ntlᴇn were of three classes, as among the Pila'tlq, and called by the same names, viz., sqᴇnä'm, seuwē'n, and seu'wa. Shamanistic contests seem to have been common and popular, and were indulged in whenever shamans of different tribes or settlements came together. Most tribes have a number of stories telling of these contests. I gathered the following from the Kwa'ntlᴇn. A certain shaman invited several others of his class to his house, and then called upon them to show their thaumaturgical powers. The first to respond to the invitation began in the usual way with his dance and seuwE'n. After a while he showed them a peculiar stone and bade them note it. He then cast it into the fire, and a moment afterwards it was heard to fall upon the roof. Another then began his dance and seuwE'n. Presently he showed them two stuffed mice. These he cast into the fire, and two live mice were seen to come out of a hole in the ground close by. A third then exhibited his 'medicine.' This man commenced his dance with a large feather in his hand. After he had been dancing a while he threw the feather into the fire, and a moment later it came up from a hole in the ground and stood up and danced. The last to perform was an old man. He begged someone to do his dancing for him ; but no one complying, he cast into the fire some native fish-hooks he had in his hand, whereupon they flew hither and thither and fixed themselves in the lips and mouths of the bystanders, from which they could not remove them till he himself did so. The stories in the native Kwa'ntlEn text below also relate instances of these shamanistic displays. The following account of some shamanistic feats was given me by an old settler who has lived among the Kwa'ntlEn people for a great many years and has an Indian wife. He relates that at a shamanistic performance at which he was present he saw a shaman take a feather and stick it apparently into a piece of rock. The stone then began to roll about, but the feather remained in it. Another wore in his cap a number of dried birds' heads. He took these out of the hat and threw them into the air, whereupon each became a living bird and flew about the shaman. Another took a bucketful of water and danced round it for a while. Presently a little fir-tree was seen to grow out of it, each branch of which was tipped with feathers. Another, to show his powers, sat with his feet and lower limbs in an oven. Presently water began to run out of the oven and put the fire out ; but when he withdrew his legs and feet the water disappeared and the fire came again.

These are samples of the thaumaturgical skill of the Salish shaman. I may add that I regard these feats as quite distinct from those more psychical conditions and manifestations before alluded to. They appear paltry beside the thaumaturgical powers of the conjurers of India, or even of our own professional wonder-mongers.

Qäls.

Qäls, the Transformer, was invoked as a deity by the Kwa'ntlEn. They believed it was he who instituted the Feasts of First Fruits and taught them to pray. According to them the muddy waters of the Fraser were caused by Qäls beating out the brains of one of his brothers and throwing them into the stream. Up to this time the waters were clear. He did this that they might the more readily catch the salmon. He also taught the SQEnä'm their *seuwE'n* or dance-songs, and bade them sing them when they wanted his help in healing their patients. According to my Kwa'ntlEn informants the Qäls were *eight* brothers. This lack of definite concepts concerning this marvellous being, and the conflicting accounts of his personality, or personalities, and character among the different coast and delta Salish tribes, would seem to indicate that his cult has been adopted by them since their migration hither, and was not one originally belonging to the whole undivided stock. Higher up the river, above the Halkōmē'lEm tribes, he does not appear to be known.

Naming Ceremonies.

These ceremonies among the Kwa'ntlᴇn appear to have been made the occasions of general festivity and feasting. Every prominent or wealthy man in the tribe would hold a naming feast as soon as his son had reached the walking age, and hire one or more members of the sqoi'aqī totem to be present and assist him to celebrate the event. His neighbours would also take advantage of the occasion to dance and sing their ancestral seuwᴇ'n. In doing this it appears to have been incumbent upon them to make generous distribution of blankets, &c. Not to do this was considered dishonouring to their ancestors and their su'līa. When all these minor performances were over, the sqoi'aqī would dance with the child to be named, holding him by the hand. If there were several members of the totem present, they would dance round the child in a circle. Only very wealthy persons could hire large numbers of the sqoi'aqī, each having to be paid many blankets for his services. After this dance was over a chief of some friendly tribe, present by special invitation for the purpose, would declare in a loud voice that the child would be known thereafter by such and such a name. These names were always ancestral names, taken from either side of the family. In the case where no sqoi'aqī were hired the father of the child to be named would mount upon the roof of the house and conduct the ceremonies there himself. A number of blankets would be stacked at his side. He would first sing his songs and perform his su'līa dance, or those of his ancestors, after which he would call out the names of those he had specially invited, and as they came forward in the order of their social rank, present them with one or more blankets each. When all his chief guests had received their presents he would *swäls* the rest among the younger men. A great feast consisting of game and fish would next be indulged in. During the feast one of the elders or a prominent guest would declare the new name of the child, and the rest would express their satisfaction and approval. It was the aspiration of every man to outdo his fellows in the number of his guests invited and the quantity of blankets and other gifts distributed. His social rank was in a great measure determined by his ability to excel in these respects. The more members of the sqoi'aqī he could hire, the larger the number of guests he could invite, and the greater the quantity of blankets and other gifts he could distribute, the higher became his social position in the eyes of his own and neighbouring tribes.

The mortuary customs of the Kwa'ntlᴇn do not appear to have differed materially from those described among the Pila'tlq. According to my Kwa'ntlᴇn informants, the men who handled and prepared the corpse for burial belonged to a special order or class, the office descending from father to son, much as did that of the *paraschites* among the ancient Egyptians. But while these among the Egyptians were despised and abhorred by their fellows, and made to live apart from the rest of the community, the *spolākwe'tsa* of the Halkōmēlᴇm were held in honour and received substantial honoraria for their services.

LINGUISTIC.

The phonology of the Kwa'ntlᴇn does not differ in any material point from that of the Tcil'qē'uk. My general remarks on the Tcil'qē'uk noun apply here also. I collected a few specimens of the incorporative noun, which I append here. The forms are not quite the same in some cases, but a common principle is seen to run throughout all the dialects :—

MakwEtl-*ksEn*-tsEn, I hurt my nose. *Cf.* the independent form *mu'ksEn.*

MakwEtl-*ālks*-tsEn, I hurt my eye. *Cf.* the terms for right and left eye.

MakwEtl-Es-tsEn, I hurt my face. *Cf.* this with N'tlaka'pamuQ independent term, of which it is an abbreviated form.

MakwEtl-tcis-tsEn, I hurt my finger or hand. This is the common incorporative form seen in all 'hand' syntheses.

MakwEtl-Hen-tsEn, I hurt my foot. Common form for 'foot' syntheses.

MakwEtl-tlina-tsEn, I hurt my ear. *Cf.* with *tlanī*, the independent term for 'ear' in N'tlaka'pamuQ.

MakwEtl-EwEts *or* EwEtl-tsEn, I hurt my back. This is an abbreviated form of the independent *slukEwEtl* = back.

It will be seen that the incorporative nouns in this dialect, though the syntheses are differently formed, are much the same as in the other dialects examined. Some are abbreviations of the independent form of the same word, others are from synonymous terms which are seen to be independent forms in other dialects.

NUMERALS.

CARDINALS.

1. nE'tsa.
2. yisē'la.
3. tlūQ.
4. Haä'sen.
5. tl'ka'tcis.
6. t'qum.
7. tsauks.
8. t'kä'itsa.
9. tūq.
10. â'pEn.
11. â'pEn-l-tE nE'tsa.
12. â'pEn-l-tE yisē'la.

20. c'kwic.
21. c'kwic i-tE nE'tsa. The other units follow in like manner.
30. tlūQEtlca.
40. Hā'senca, Hā'sentlcQ.
50. tlu'kEtlca.
60. t'qu'mEtlca.
70. tsau'ksEtlca.
80. t'kai'tcEtlca.
90. tūqEtlca.
100. nE'tsowits.
1000. â'pEnEtlcä'lits.

The 'teens' all follow in like manner.

The conjunction seen here is the commonest form in the Salish dialects for 'and'; the other element *tE* is the definite article.

ORDINALS.

1st. yu'än.
2nd. sIsä'lEs.
3rd. stlūQs.
4th. sEHâ'sEns.
5th. stlka'tcEs.

6th. st'qu'ms.
7th. stsau'k's.
8th. st'kai'tsEs.
9th. stūqs.
10th. sâ'pEns

It will be observed that the ordinal numbers differ in Kwa'ntlEn from those found in Tcil'Qē'uk, which are formed by cumbersome circumlocutions. Here, with the exception of 'first,' the formative element *s* is added after the manner of forming abstract nouns. It differs, however, from the abstract noun in having *s* both prefixed and suffixed. A comparison of the ordinal numbers in the different Salish dialects is very interesting, scarcely any two agreeing in form.

There are in Kwa'ntlEn a great number of class numerals. They are found among the ordinals as well as among the cardinals. Thus we have :—

yū'än, the first man.
sIyä'sElis, the second man.
sQä'lis (?), the third man.

sEQâtlē'lis, the fourth man
stlkätsä'lis, the fifth man.
sEpä'lis, the tenth man.

PARTITIVE NUMERALS.

first part, tnE'tsamöt.
second part, yisē'lamo.

third part, tlū'QEmot.
fourth part, Häüsemot.

CLASS NUMERALS.

1 man, nō'nsa.
2 men, yüaise'la.
3 „ tlūQē'la.
4 „ Häsê'la.
5 „ tlkatcâ'la.
6 men, t'qu'mela.
7 „ tsauksä'la.
8 „ t'kaitesE'äla.
9 „ tū'qäla.
10 „ â'päla.

—	Houses	Canoes	Trees	Poles, &c.	Blankets and soft-feeling things	Round things	Bands of cattle, booms of logs, huts, &c.
1	nE'tsantQ	nEtsaQi'tl	snE'tsalp	snE'tsamats	nE'tsElwut	nE'tsus	-awok
2	sEm'p'tQ	samōQi'tl	sī'sälp				
3	tlEQautQ						

DISTRIBUTIVES.

These are regularly formed by reduplicating the first syllable of the cardinal numbers, thus :—

nEtnE'tsa, one each; yisyi'sEla, two each; âpâ'pEn, ten each.

MULTIPLICATIVES, OR NUMERAL ADVERBS.

After the first two these are regularly formed by suffixing the formative particle *atl* to the cardinal numbers, as in N'tlaka'pamuQ, thus :—

nE'tsauQ, once; säma', twice; tlūQa'tl, thrice; Haä'senatl, four times; â'pEnatl, ten times.

PRONOUNS.

PERSONAL PRONOUNS.

These, as is common in the Salish tongues, are of three classes: the independent, the inflectional or copulative, and the incorporative or synthetic.

The independent are:—

ens, I, me.
nō'a, thou, thee.
tEsä' or t'sä', he, him.
sE or ça, she, her.
tl'ne'mEtl, we, us.
tli'lEp, tl'wilEp, ye, you.
t'sa-lī (common), they.
yē-sä', they (masc.).
yê-çä' or yēsE', they (fem.).

Besides the above forms for the third person we find the *tō-tla* or *tau-tla*, he, him; *ço-tla* or *çau-tla*, she, her; *tau'-tlālEm*, they, them; *tla'lEm*, they, them, seen in the Tcil'Qē'uk. The usage of these may best be seen in the Kwa'ntlEn text below. The first person singular has a selective form, thus: *tE ensa*. In Kwa'ntlEn the presence of the demonstrative *tE* with the pronominal forms appears always to give a selective significance to them. It is not regularly compounded with them as in Tcil'Qē'uk and some other dialects, where its uniform use has apparently caused the pronouns to lose their selective force. The Kwa'ntlEn seems, therefore, to show us the reason why this demonstrative particle came to be compounded with the pronominal forms. The Kwa'ntlEn use also an emphatic form of the independent pronouns, as follows:—

wa-n-e'nsa, I myself.
wa-En-nō'a, thou thyself.
wa-tla (tō-tla), he himself.
wa-tla (sō-tla), she herself.
wa-tl'nEmEtl, we ourselves.
wa-tl'wilEp, you yourselves.
wa-tla-lEm, they themselves.

A more literal translation of this would be: It is I myself, &c., &c.

The inflectional or copulative forms are as follows:—

-tsEn, I.	-tst, we.
-tcûQ, thou.	-tcäp, you.

The third person has no inflectional pronoun; but when the subject of the verb is the third person the particle *Es* is suffixed to the stem. This *Es* is, I believe, a substantive verb. It appears only in transitive verbs, and its presence converts the verb into a noun, giving it the character partly of an infinitive and partly of a gerund. This is clear from the fact that it appears in both numbers alike; and if we want to distinguish between the singular and the plural, the masculine and the feminine, we must add the demonstrative forms used for the third person to it.

The forms for the first and second persons, as may be seen in the paradigm of the verb below, undergo modification in the conditional, optative, and other moods.

In the present and the simple future tenses of the verb the pronouns are regularly suffixed to the verb stem in Kwa'ntlEn; but when the verb takes on auxiliary verbs and modifying particles, the pronoun is generally attached to one or other of these. In certain expressions, particularly those of an obligatory character, this rule is broken and the pronoun is attached to the verb stem (*see under* 'Verbs').

It will be noticed that the first person plural differs in form from that found in Tcil'Qē'uk, which corresponds to the Sk·qō'mic.

The locative adverbial particle *nī* is regularly used with the third person when he or she is absent, or when the action was done in the past. Thus: *nī* kai'EtEs kw'sEn skwomai', he killed my dog; *nī* ts' stElEkai'û, he has some horses.

INCORPORATIVE OR SYNTHETIC PRONOUNS.

These are best seen in their syntheses. Thus:—

tsâ'wEt-*sâmâ'*-tsEn-tsa, I will help thee.	tsâ'wEt-*tâ'la*-tsEn-tsa, I will help you.
tsâ wEt-tsEn-tsa, I will help him.	tsâ'wEt-tsEn-tsa, I will help them.
tsâ w-*iç*-tcûQ-tsa, thou wilt help me.	tsâ'wEt-*tâ'lōQ*-tcûQ-tsa, thou wilt help us.
tsâ'wEt-tcûQ-tsa, thou wilt help him.	tsâ'wEt-tcûQ-tsa, thou wilt help them.
tsâ'w-*iç*-tcäp-tsa, you will help me.	tsâ'wEt-*tâ'lōQ*-tcäp-tsa, you will help us.
tsâ'wEt-tcäp-tsa, you will help him.	tsâ'wEt-tcäp-tsa, you will help them.
tsâ'w-Es-*sâmps*-Es-tsa, he will help me.	tsâ'wEt-*tâ'lōQ*-Es-tsa, he will help us.
tsâ'w-Es *sâm*-tsa, he will help thee.	tsâ'wEt-*tâ'lEm*-tsa, he will help you.
tsâ'w-*iç*-Es-tsa, they will help me.	tsâ'wEt-*tâ'lōQ*-Es-tsa, they will help us.
tsâ'w-Es-*sâ'mpts*-tsa, they will help thee.	tsâ'wEt-*tâ'lEm*-tsa, they will help you.
tsâ'wa-*tsamâ'*-tst-tsa, we will help thee.	tsâ'wa-*tâ'la*-tst-tsa, we will help you.
tsâ'wEt-tst-tsa, we will help him.	tsâ'wEt-tst-tsa, we will help them.

tsâ'wa *tEl*-tst-tsa, we will help one another.

The stem of this verb 'to help' is *tsâ'wa*. The termination *-Et* is the sign of the active verb. It is very interesting to observe how this suffix is sometimes dropped in the singular forms, but rarely in the plural. As in the other Salish dialects examined, there are no specialised forms for the third person.

It will be seen from the following examples that there are secondary forms for the synthetic pronouns in Kwa'ntlEn. I did not observe this feature in the Tcil'Qē'uk.

kwEts-*nâla*-tsEn, I see you; kwEts-*nâ'mâ*-tsEn, I see thee.
kwEts-nûq-tsEn, I see him, her, it, them.
nē-tsEn-kwEts-nuq, I saw him, her, it, them.
kwEts-*nâ'mâ*-tsEn-tsa, I shall see thee; kwEts-*nâ'la*-tsEn-tsa, I shall see you.
(nI-) kwEts-*manis*, he saw me; (nI-) kwEts-nâ'lōHis, he saw us.
(nI-) kwEts-*nâm*, he saw thee; (nI-) kwEts-nâ'lEm, he saw you.

I think this difference in form is due to the nature of the verb, the former being used with active, the latter with neuter verbs. These latter forms bear a resemblance to forms seen in the passive voice of the verb. The *nûq* of the third person is the determinative particle treated of elsewhere. The 'him,' &c., here referred to is a particular, determined 'him'; hence the use of *nûq*.

POSSESSIVE PRONOUNS.

The differences between these and the corresponding forms in Tcil'Qē'uk are not very great; but such as they are, they have an interest for the linguistic student. One of the most notable of these differences is the presence and use of *n* in the second person singular. The same feature is seen in some of the interior dialects. The choice between the *En* and the *Es* forms seems to be guided by euphonic laws, as they are not used interchangeably. There are also distinct forms to mark the object possessed as feminine or masculine. I did not detect this feature in Tcil'Qē'uk, although it appears to exist in the Halkōmē'lEm speech generally. The form for the first person singular in Kwa'ntlEn, as will be seen, differs from the corresponding form in Sk·qō'mic and Tcil'Qē'uk. The difference between the simple form and that compounded with the demonstrative in Kwa'ntlEn is that the former is general in significance, the latter selective. The rule for the use of the two forms will be best understood by an example, thus: *nE* is used in answer to such a question as 'Whose is this?' when only one person is present besides the questioner. If there are several others present, then the answer will always be *TE-nE*. It is clear from this that the particle *tE* used with the pronominal forms is the regular demonstrative.

FIRST PERSON.

Singular.

nE, my (common form with masculine object).
tE-nE, or shortly tE-n, my (selective form with masculine object).
nE, my (common form with feminine object).
sE-nE, or shortly sE-n, my (selective form with feminine object).

It is clear from these examples that the formal gender of the pronouns is derived from the demonstrative, which alone has distinct forms for masculine and feminine.

Plural.

. . . tst, our (common form with masculine or feminine object).
tE . . . tst, „ (selective form with masculine object).
sE . . . tst, „ (selective form with feminine object).

SECOND PERSON.

Singular.

En or Es, thy (common form with masculine or feminine object).
tE-En or tE-Es, thy (selective form with masculine object).
sE-En or sE-Es, thy (selective form with feminine object).

Plural.

En or Es . . . ElEp, your (common form with masculine or feminine object).
tE-En or tE-Es . . . ElEp, your (selective form with masculine object).
sE-En or sE-Es . . . ElEp, your (selective form with feminine object).

THIRD PERSON.

Singular

. . . s, his or hers (common form with masculine or feminine object).
tE . . . s, his (selective form with masculine or feminine object).
sE . . . s, her („ „ „ „).

The plural is the same. If it is desirable or necessary to distinguish them from the singular, the demonstrative forms for the plural are added.

The above forms are used when the object possessed is present and visible. The 'invisible' and 'absent' forms in Kwa'ntlEn differ a little from the corresponding forms in Tcil'Qē'uk. They are as follows:—

Object Present but Invisible to Speaker.

kwE-nE = my, as kwE-nE skwomai, my dog (object masculine).
This form is frequently contracted to kwEn'.
k'tlEn = my, as k'tlEn mūsmūs, my cow (object feminine).

Object Absent and Invisible to Speaker.

K's-sā-nE, often contracted to k's'ān', my (object masculine).
K's-tlEn, my (object feminine).

The same elements are used with the pronominal forms of the other persons.

EMPHATIC FORMS.

The same rule applies to the other pronominal forms with respect to common and selective, masculine and feminine forms.

nE-swa, my own.	sā'atl, our own.
En-swa, Es-swa, } thy own.	Es-swa'ElEp, your own.
tō-swas, his own.	tō-swas, their own.
sE-swas, her own.	

SUBSTANTIVE FORMS.

nE-swa, mine.	sā'autl, ours.
Es-swa, thine.	Es-swa'ElEp, yours.
swas, his, hers.	swas (a'tltEn), theirs.

POSSESSIVE WITH *Verbum Substantivum.*

tla-wa-n'-swa, it is my or mine; tla-wa-sā'autl, it is our or ours.
tla-wa-En-swa, it is thy or thine; tla-wa-EswaElep, it is your or yours.
tla-wa-swas, it is his, her, or hers; tla-wa-swas (atltEn), it is their or theirs.

POSSESSIVE WITH *Verbum Substantivum* AND DEMONSTRATIVE.

tla-n'-swa ti, this is mine; tla sā'autl ti, this is ours.
tla swa ti, this is thine; tla-EswaElep ti, this is yours.
tla swas ti, this is his, hers; tla-swas (atltEn), this is theirs.

The Kwa'ntlEn also use the prepositional form for the third person when the owner's name is mentioned. Thus: skwomai' *tla* John, the dog of John. Possession or ownership is also marked in Kwa'ntlEn in the following manner:—

ē-tsEn ts' skwomai, I have or own a dog.
n-ē-tcūQ ts' skwomai, you have a dog.
ē-tst ts' skwomai, you and I have a dog.
ē-tst ts' skwomkwomai', we have some dogs.
ē-tst ts' skwomai' ē-tōtla, he and I have a dog.

This last is particularly interesting in its construction. The particle *ts'* which is seen here appears to be wanting in the corresponding expression in Tcil'Qé'uk.

INTERROGATIVE PRONOUNS.

Singular—Wet? who? Wet kwa yā'is tE lā'lEm? who made this house?
Plural—Wet-yIsa' or tlatlswet. Wet tcūQ? who are you? Wet t'sā'? who is that?
Wet-yIsā'? who are they?
Tō-wet? whose? Tō-wet slais tE I? whose work is this? or, who did this?
Tō-wet lā'lEm? whose house is that? Tō-wet tE-nI? whose is that?
Stam? what? Stam t'sā? what is that? Stam kwa Es-stlē? what do you want?
But 'what man?' is thus rendered: wet swē'Eka?
Kwa nEtsa? which? *ad litt.* 'a one?'

Demonstrative Pronouns.

tᴇ (masc.), sᴇ (fem.), t'sä' or tᴇsä' (common), he she.
yēsä' (masc.), yēçä' (fem.), t'sä-lī (common), they.
tᴇ-ī (masc.), tī, tᴇ-nā' (masc.), sᴇ-nā' (fem.), this, these.
tᴇ-nī' (masc.), sᴇ-nī' (fem.), that those.

Indefinite Pronouns.

wet-âl, anyone; au'ita-wet, no one.
yᴇsä', someone; used as the *on* in French.

Reflexive Pronoun.

nâmit, self.

Demonstratives.

These do not differ from the Tcil'Qē'uk forms already given, except in the substitution of *n* for *l*. The Kwa'ntlᴇn, however, appear to express the distinction between the attributive and the predicative adjective in conjunction with a demonstrative differently. Thus they say *ō tī lā'lᴇm*, this house is good; but *ō tᴇ lā'lᴇm*, this is a good house. In Tcil'Qē'uk the distinction is effected by a difference in the order of the words; in Kwa'ntlᴇn by the use of different demonstratives.

ARTICLES.

These are identical with those in TcilQē'uk, and their functions appear to be the same.

ADJECTIVES AND ADVERBS.

My remarks on these in the Tcil'Qē'uk apply equally here. The syntax of these is apparently the same in all the Halkōmē'lᴇm dialects. It may be added, however, that a study of the native texts reveals the fact that certain temporal adverbs 'govern' the subjunctive mood. Thus I may say *sqēlins*, 'he stands'; but 'he stands awhile' must be expressed thus: *tō-hī's k's-qēlins*. Again, *amō's*, 'he came,' but wīâç-ᴇ-tl *k's*-ämē's, 'often he used to come.' Numerous other examples will be found in the native text.

The comparison of adjectives in the Kwa'ntlᴇn seems to be more regular than in Tcil'Qē'uk. There appears to be an equivalent to our comparative sign *-er*. Thus:

Positive.	*Comparative.*	*Superlative.*
ē, good.	tû or tō-ē, better.	yᴇlau'wel-ē, best.
k·ᴇl, bad.	tû or tō-k·ᴇl, worse.	yᴇlau'wel-k·ᴇl, worst.

This *tū* or *tō* which marks the comparative degree is probably the particle *to* which is seen in the pronominal forms of the third person and in certain other pronominal and demonstrative expressions. It is interesting to remark that the same particle appears compounded with *wa* in the comparative in N'tlaka'pamuQ.

PREPOSITIONS, CONJUNCTIONS, AND CONJUNCTIVE ADVERBS.

The forms and functions of these will best be gathered by a study of the native text given below.

VERBS.

The inflection of the verb in Kwa'ntlᴇn is effected, as in the other dialects examined, by means of particles and auxiliary verbs. The principal of these are:—*ē*, *e-tl*, *ī-tl*, or *ē-tl*, *nō*, *tl*, *wᴇ-tl*, *wā*, *nē-tl*, *tca*, or *tsa*. The functions of these are best grasped by an examination of the paradigms and the native text.

VERBA SUBSTANTIVA.

Of these *ē*, *ī-tl*, *wā*, and *ᴋs* are the most important. The first does not appear to be used apart from other verbs. It seems to have the sense of our *am*, &c. The last three are used both independently and as auxiliaries to other verbs. ī-tl or ē-tl appears to be the preterite of *ē*, it being found only in past tenses, thus: tlᴇmōQ *ī-tl* tsilakatlitl, 'it rained yesterday.' *Wā* is used differently in some of the Halkōmē'l-ᴇm dialects from what it is in Sk·qō'mic and N'tlaka'pamuQ. In the Kwa'ntlᴇn it appears chiefly in conditional clauses. It seems to be the chief sign of the subjunctive forms (*see* the verbs). It is seen also in verbal syntheses implying obligation on the part of the agent, thus: *wā*-kwakwot-tsᴇn, 'I must strike,' &c. It is found likewise in sentences that begin with a temporal adverb, thus: wla'tl kwᴇns *wā* k·ā'käi, 'I am often sick.' In some instances it is used interchangeably with ē-tl or ī-tl, thus: talmō'ʜse-tcūQ *wā* (or *etl*) k·ākau'ōQ, 'When you are sick you should take medicine.' Again, it and some of the others are seen to enter largely into the construction of conjunctions or connectives. In the continuous native text below it will be seen that *ē'-tlās-wä*, *tla's-wä*, and *ē'-tlās-ᴋs-wä* are regularly employed to connect the sentences. It is very difficult to translate these expressions into English; and no two dialects seem to use the same forms. *ᴋs* appears regularly in the third persons as an auxiliary to transitive verbs. Its presence converts the verb into a verbal noun. It appears also with the pronouns of all the persons in certain constructions. Thus it may be seen in the form *kw'ᴇn-ᴋs* in the sentence, Huta kwᴇ-n-*ᴋs* k·ᴇl, 'He said I was a bad man.' Again in Huta kw'-*ᴋs* nᴇms, 'He said he was going.'

INTRANSITIVE VERBS.

sick, *k·ākäi*.

Present Tense.

These are formed in Kwa'ntlᴇn by the simple juxtaposition of the verb stem, noun or adjective, and the inflectional pronouns, thus:—

Sing.	k·ā'käi-tsᴇn, I am sick.	Plur.	k·ā'käi-tst, we are sick.	
	k·ā'käi-tcūQ, thou art sick.		k·ā'käi-tsap, you are sick.	
	k·ā'käi (t'sä, tō'tla), he is sick.		k·ā'käi (a'tltᴇn), they are sick.	
	k·ā'käi (çä, sō'tla), she is sick.		k·ā'käi (tō-tlā'-lᴇm (masc.) tlā'-lᴇm (fem.)	they are sick.

The locative particle *nī* is prefixed to the third person, singular and plural, to mark absence. Of the two forms in the third person plural, the former is in Kwa'ntlᴇn employed in a particular sense to indicate the members of the speaker's own family, the latter in a general sense.

Present Perfect and Responsive Tense.

Singular.	*Plural.*
ē-tsᴇn-k·ā'käi, I am sick.	ē-tst-k·ā'käi, we are sick.
ē-tcūQ-k·ā'käi, thou art sick.	ē-tcap-k·ā'käi, you are sick.
ē-k·ā'käi, he or she is sick.	ē-k·ā'käi, they are sick.

If it is desirable to distinguish between masculine and feminine, singular or plural, in the third person, the demonstrative forms given above in the present tense are added; but generally the subject, when in the third person, requires no personal elements, the sex and number being understood. The forms of this tense are employed only in response to direct questions. A plain statement of fact is expressed by the forms of the present tense. It was the same in the Sk·qō'mic. I have rendered the auxiliary *ē* here by 'am.' The natives who understand English do the same; but it is not the equivalent of our substantive verb. Besides conveying a statement of present condition or action, it carries with it also a sense of past action or condition. A more exact translation of the term would be: 'I am being sick,' &c. &c. When *ē* is prefixed to a transitive verb the tense is then really an *immediate* past, and is best translated by 'I have just,' &c., or by the substantive verb with the active participle (see under 'Transitive Verbs,' below).

PRESENT PERFECT CONTINUOUS AND RESPONSIVE TENSE.

This differs from the other by the presence of the temporal particle Qon = 'still, 'yet,' thus:—

ē-tsEn-Qon-k·ā'käi, I am still sick; ē-tst-Qon-k·ā'käi, we are still sick.

PRETERITE.

Singular.	*Plural.*
k·ā'käi-e-tl-tsEn, I was sick.	k·ā'käi-e-tl-tst, we were sick.
k·ā'käi-e-tl-tcũQ, thou wast sick.	k·ā'käi-e-tl-tcap, you were sick.
k·ā'käi-e-tl, he or she was sick.	k·ā'käi-e-tl, they were sick.

The locative particle *nī* is added to the third person in both numbers to mark absence.

PAST PERFECT TENSE.

ē-tl-tsEn-k·ā'käi, I have been sick; ē-tl-tst-k·ā'käi, we have been sick.
The other persons follow in like manner.

PLUPERFECT TENSE.

There is no difference between this and the past perfect tense.

FUTURE TENSE.

k·ā'käi-tsEn-tsa, I shall be sick; k·ā'käi-tst-tsa, we shall be sick.

The other persons follow regularly.

It is very noticeable how regularly the Salish dialects of this region *prefix* the verb stem in the future tense.

PERIPHRASTIC FUTURES.

k·ā'käi-yũQ-tsEn-tsa, I think I am about to be sick.
sē·'sI-tsEn-wa-k·ā'käi-an, I am afraid I shall be sick.
Iwā'wā k·ā'käi-tsEn, perhaps I shall be sick.

OPTATIVE FORMS.

k·ā'käi-ā'nōQ tlā'al, I wish I was sick.
n'-stlē kwEns-k·ā'käi, I want to be sick.

CONDITIONAL FORMS.

kwEns or kwEdEs k·ā'käi, when I am sick.
kwEs k·ā'käi, when thou art sick.
k's k·ā'käi-tst, when we are sick.
kwEs k·ā'käi-ElEp, when you are sick.

wE-nē-En-e-tl-k·ā'käi, if I am sick, *or* if I were sick.
wE-nē-Et-e-tl-k·ā'käi, if we are sick, *or* if we were sick.
wE-nē-ōQ-e-tl-k·ā'käi, if thou art sick, *or* if thou wast sick.
wE-nē-ap-e-tl-k·ā'käi, if you are sick, *or* if you were sick.
wE-nē-Es-e-tl-k·ā'käi, if he is sick, *or* if he were sick.

QUOTATIVE FORMS.

Hu'ta tsa kwEs ē-k·ā'käi, he said thou wast sick.
ē-Hu'ta k's-ē-tst k·ā'käi, he said we were sick.
ē-Hu'ta k's-Elap k·ā'käi, he said you were sick.

DUBITATIVE FORMS.

Iwā'wā k·ā'käi-tsEn, I may be sick; Iwā'wā k·ā'käi-tst, we may be sick.

The other persons follow regularly in like manner.

It is worthy of notice that these dubitative forms have, thus far, been different in each dialect examined.

NEGATIVE FORMS.

aua-tsᴇn k·ā'käi-ᴇn, I am not sick.
aua-t-st k·ā'käi-ᴇt, we are not sick.

The other persons follow regularly in like manner.

auänōQ tlā'al k·ā'käi-ᴇn, I don't want to be sick.
aua kwᴇnᴇs wiä'ç k·ā'käi, I am not often sick.

MISCELLANEOUS FORMS.

nᴇskwä'lûon ē-tsᴇn-k·ā'käi, I think or believe I am sick.
k·ā'käis tām (t'sa) tsa, this will make you sick.
k·ā'käis tām ʜis tsa, this will make me sick.
ē'-ā-tcũQ-k·ā'käi ? are you sick ?
ē-tsᴇn-k·ā'käi, I am sick, *or* shortly ē-tsᴇn, I am.
ē-ā·k·ā'käi? is he sick? ē-k·ā'käi, he is sick, *or* shortly ē he is.
wia'ç (or wiatl) kwᴇns wa k·ā'käi, I am often sick.

TRANSITIVE VERB.

The principal tense signs of the transitive verb are: ē, present perfect or responsive sign; *nē* and *nē-tl* preterit; *nē . . . wᴇ-tl*, past perfect and pluperfect; and *tsa*, future.

ACTIVE VOICE.

kwä'kwot, to strike.

PRESENT TENSE.

kwä'kwot-tsᴇn, I strike ; kwä'kwot-tst, we strike.
„ -tcũQ, thou strikest ; „ -tcap, you „
„ -ᴇs (tᴇ (masc.) sᴇ (fem.) present, he or she strikes.
nI „ -ᴇs „ „ absent „ „ „
„ -ᴇs (tōtlâ'lᴇm (masc.) sōtlâ'lᴇm (fem.) present, they strike.
nI „ -ᴇs „ „ „ „ absent, „ „

PRESENT PERFECT CONTINUOUS AND RESPONSIVE TENSE.

ē-tsᴇn-kwä'kwot, I am striking; ē-tst-kwä'kwot, we are striking.

The other persons follow regularly in like manner.

I may add here that 'gender' and 'number,' 'absence' and 'presence' of the third person are uniformly expressed in all the tenses as in the present tense above.

In the past tenses the Kwa'ntlᴇn distinguish between a recent and a more remote action thus:

RECENT PAST TENSE.

nē-tsᴇn-kwä'kwot, I struck; nē-tst-kwä'kwot, we struck.

The other persons follow regularly in like manner.

REMOTER-PAST TENSE.

nē-tl-tsᴇn-kwä'kwot, I struck; nē-tl-tst-kwä'kwot, we struck.

The other persons follow regularly in like manner.

PAST PERFECT AND PLUPERFECT TENSE.

nē-tsᴇn-wᴇ-tl-kwä'kwot, I had struck; nē-tst-wᴇ-tl-kwä'kwot, we had struck.

The other persons follow regularly in like manner.

FUTURE TENSE.

kwä'kwot-tsᴇn-tsa, I shall strike; kwä'kwot-tst-tsa, we shall strike.

The other persons follow regularly in like manner.

Besides this regular form, the future is sometimes expressed by adding *näm*, 'to go,' to the verb instead of the particle *tsa*. But this can only be done with verbs of action where motion is possible, as: 'I am going to run,' and 'I am going to strike,' &c. It would be impossible to say 'I am going to be sick,' 'I am going to be rich,' &c., with *näm*.

IMPERATIVE MOOD.

The imperative inflection in Kwa'ntlᴇn is *tla*, thus:

kwä'kwot-tla! strike!
kwä'kwot-tcūꞯ, strike thou; kwä'kwot-tcap, strike ye.
ē-tla-kwä'kwot, let me (or us) strike; tīmit cū kwᴇs kwä'kwot, strike hard.

The difference between the personal and the impersonal form is interesting. The impersonal form in *-tla* is used only when the speaker sees the agent about to strike; or when he is hesitating whether he will strike, &c., or not. The personal forms are those commonly employed in giving an order or command.

FORMS IMPLYING OBLIGATION ON THE PART OF THE AGENT.

wā-kwä'kwot-tsᴇn, I must strike.
wā-kwä'kwot-tcūꞯ, you „ „
wᴇ-tl-kwä'kwot-tst, we ought to strike.
„ „ -tcap, you „ „ „

NEGATIVE FORMS.

PRESENT TENSE.

au'a-tsᴇn kwā'kwot-ᴇn, I strike not; au'a-tst kwā'kwot-ᴇt, we strike not.
au'a-tcuꞯ kwā'kwot-ōꞯ, thou strikest not; au'a-tcap kwā'kwot-äp, you strike not.
au'a kwā'kwot-ᴇs, he strikes not; au'a kwā'kwot-ᴇs (äatlten), they strike not.

PRETERITE.

au'a-tsᴇn nē-'n-kwā'kwot, I did not strike; au'a-tst nē-ᴇt-kwā'kwot, we did not strike.

au'a-tcuꞯ nē-ōꞯ-kwā'kwot, thou didst not strike; au'a-tcap-nē-äp-kwā'kwot, you did not strike.

au'a nē-ᴇs-kwā'kwot, he did not strike; au'a nē-ᴇs-kwā'kwot, they did not strike.

FUTURE.

au'a-tsᴇn tsa-kwā'kwot-ᴇn, I shall not strike; au'a-tst tsa-kwā'kwot-ᴇt, we shall not strike.

au'a-tcuꞯ tsa-kwā'kwot-ōꞯ, thou wilt not strike; au'a-tcap tsa-kwā'kwot-äp, you will not strike.

au'a-tsa kwā'kwot-ᴇs, he will not strike; au'a-tsa kwā'kwot-ᴇs, they will not strike.

IMPERATIVE.

au'a-tcūꞯ kwā'kwot-ōꞯ! don't strike it!
au'a-tcūꞯ kwā'kw'k·'samç-ōꞯ, don't strike me.
au'a-tst kwā'kwot-ᴇt, don't let us strike it.

It is interesting to observe that the Kwa'ntlᴇn uniformly suffix the regular subject pronoun in negative sentences to the negative, adding a secondary form to the verb stem as well. This is not an uncommon feature of the Salish tongues; nor is this attachment of the pronominal forms to the adverb confined to the adverbs of negation only. Yet not all adverbs are thus treated.

CONDITIONAL FORMS.

wä-kwā'kwot-tsᴇn, if I strike.	wä-kwā'kwot-ᴇt, if we strike.
„ „ -tcūꞯ, if thou strikest.	„ „ -äp, „ you „
„ „ -ᴇs, if he strike.	„ „ -ᴇs, „ they „

wä-kwā'kwot-ᴇn-ē-tl, if I were to strike; wä-kwā'kwot-ᴇt-ē-tl, if we were to strike.
,, ,, -ōQ-ē-tl, ,, thou wast to ,, ; ,, ,, -äp-ē-tl, if you ,, ,,
,, ,, -ᴇs-ē-tl, ,, he were to ,, ; ,, ,, -ᴇs-ē-tl, if they ,, ,,
ē-wä'-wä-kwā'kwot-tsᴇn, I may strike; ē-wä'-wä-kwā'kwot-tst, we may strike.

The other persons follow regularly in like manner.

kwᴇns nē-wᴇ-tl-kwā'kwot, when I strike or struck it.
k's-nē-wᴇ-tl-kwā'kwot-tst, when we strike or struck it.

OPTATIVE FORMS.

hᴇ-stlē kwᴇns-kwā'kwot, I wish I could strike it, or I desire to strike it.
,, kwᴇs-kwā'kwot-tst, ,, we ,, ,, or we ,, ,,
,, ,, -kwā'kwot, ,, thou couldst strike it.
,, ,, -kwā'kwot-äp ,, you could ,,
kwā'kwot-ōQ tlaā'l, I wish you would or could strike it.
,, -ᴇt ,, ,, we could strike it.
nē-wä-stlēs k's-kwā'kwots? did he want to strike it?

INTERROGATIVE FORMS AND REPLIES.

nē'-ā-kwā'kwotᴇs? did he strike it?
nē-kwā'kwotᴇs, he did strike it.
nē'-ā-tcūQ-kwā'kwot? did you strike it?
nē-tsᴇn-kwā'kwot, I did strike it, *or* shortly, nē-tsᴇn, I did.
kwā'kwot-ᴇ-tst? ought we to strike it?

The interrogative sign is *ā* in Kwa'ntlᴇn. In S·qō'mic it is *ō*.

ITERATIVE FORMS.

ē-tsᴇn-wä-kwā'kwōkwot, I am repeatedly striking it.
ē-tst-wä ,, we are ,, ,,
wä-kwā'kwōkwotᴇs, he is striking it all the time.
kwā'kwōkwot-tcūQ! keep on striking it!

All iterative or prolonged action is uniformly expressed by reduplication as above.

DEPRECATIVE FORMS.

au'a-tcūQ kwā'kwot-ōQ, please don't strike it.

These forms differ from the negative indicative forms only in sound. The final *a* of the negative is drawn out in a beseeching tone in the deprecative forms.

RECIPROCAL FORMS.

nē-tst-kwā'kwot-al, we struck each other.
nē-tcap-kwā'kwot-al, you ,, ,,

INFINITIVE FORMS.

kwā'kwot, to strike; nē-kwā'kwot, to have struck.

PARTICIPLES.

kwā'kwōkwot, striking; gerund, skwā'kwot.

The stem of this verb is *kwākw* or *kwākq*. The termination *-ot* or *-ut* or *ᴇt* is a formative element. It is suffixed to the stem of any active verb when the 'it' is an indefinite object. It is the indeterminative of action. It may be replaced by *nūq* or *nōq*, the determinative of action. Thus, *nē-tsᴇn-kwā'kw'nūq*, I struck it. When *nūq* is suffixed the 'it' always relates to a known, determined object.

PASSIVE VOICE.

kwākQ, struck.

PRESENT PERFECT OF ACCIDENTAL ACTION.

kwâk·'nē'lEM, I am struck ; kwâk·'nâ'lEm, we are struck.
kwâk·'nâ'm, thou art „ ; kwâk·'tsa'p, you „

PRESENT PERFECT OF PURPOSIVE ACTION.

kwâkQEsē'lEm, I am struck ; kwâkQEtâ'lEm, we are struck.

IMMEDIATE PAST OF ACCIDENTAL ACTION.

ē-kwâk·'nē'lEm, I am just struck ; ē-kwâk·'nâ'lEm, we are just struck.

IMMEDIATE PAST OF PURPOSIVE ACTION.

ē-kwâkQEsē'lEm, I am just struck ; ē-kwakQEtâ'lEm, we are just struck.

RECENT PAST OF ACCIDENTAL ACTION.

nē-kwâk·'nē'lEm, I was struck ; nē-kwâk·'nâ'lEm, we were struck.

RECENT PAST OF PURPOSIVE ACTION.

nē-kwâkQEsē'lEm, I was struck ; nē-kwâkQEtâlEm, we were struck.

REMOTER PAST OF ACCIDENTAL ACTION.

nē-tl-kwâk·'nē'lEm, I was struck ; nē-tl-kwâk·'nâ'lEm, we were struck.

REMOTER PAST OF PURPOSIVE ACTION

nē-tl-kwâkQEsē'lEm, I was struck ; nē-tl-kwâkQEtâlEm, we were struck.

PAST PERFECT OF ACCIDENTAL ACTION.

kwâkQ'nēlEm-e-tl, I have been struck ; k·wakQ'nâlEm-e-tl, we have been struck.
nē-tsEn kwâkQ, I have been struck ; nē-tst-kwâ-kQ, we have been struck.

PAST PERFECT OF PURPOSIVE ACTION.

kwâkQEsâ'mHEs-e-tl, I have been struck; kwâkQEtâlōQHEs-e-tl, we have been struck.

PLUPERFECT.

ē-tl-tsEn kwakQ, I had been struck ; ē-tl-tst-kwakQ, we had been struck.

FUTURE.

kwâkQ'nēlEm tsa, kwâkQ-tsEn-tsa, I shall be struck ; kwâkQ'nâlEm, kwâkQ-tst-tsa, we shall be struck.

kwâkQEsEt-tsEn-tsa, I shall strike myself ; kwâkQ'EsEt-tst-tsa, we shall strike ourselves.

CONDITIONAL FORMS.

wä kwâkQEsElEm, if I am struck ; wä kwâkQEsEt-Et, if we are struck.
wE-nē-Es-e-tl-kwâkQEsēlEm, if I should be struck.
wE-nē-Es-e-tl-kwâkQEtâlEm, if we should be struck.
wä-kwâkQEsE't-En, if I strike myself ; wä-kwâkQEsEt-Et, if we strike ourselves.
wä-kwâkQEsät-ōQ, if thou strike thyself ; wä-kwâkQEsät-üp, if you strike yourselves.

wE-nē-En-e-tl-kwâkQ, if I have been struck ; wE-nē-Et-e-tl-kwâkQ, if we have been struck.

wE-nē-ōQ-e-tl-kwâkQ, if thou hast been struck ; wE-nē-üp-e-tl-kwâkQ, if you have been struck.

wE-nē-Es-e-tl-kwâkQ, if he has been struck; wE-nē-Es-e-tl-kwākQ, if they have been struck.

nē-tl-tsEn-s't-wa-kwākQ, I may have been struck; nē-tl-tst-s't-wa-kwākQ, we may have been struck.

REFLEXIVE FORMS.

wākQ-nā'mit-tsEn, I strike myself; kwākQ-nā'mit-tst, we strike ourselves.
kwākQ-nā'mit-e-tl-tsEn, I struck myself; kwākQ-nā'mit-e-tl-tst, we struck ourselves.

MISCELLANEOUS FORMS AND EXPRESSIONS.

I have a dog, ē-'tsEn ts' skwomai'.
You have a dog, nētcûQ ts' skwomai'.
You and I have a dog, ē-tst ts' skwomai'.
You and I have dogs, ētst ts' skwomkwomai'.
We have some horses, ētst ts' stE'lEkaiû.
He and I have some dogs, ētst ts' skwomkwomai' ē-tō'tla.
We have some horses, stE'lEkaiû-tst.
He has some horses, nI ts' stE'lEkaiû.
My dog is black, skēq tE n' skwomai'.
Your dog is white, pEk tE es skwomai'.
His dog is white, pEk tE skwomai's.
Our house is old, siā'lakwa tE lā'lem-tst.
My hat is on the table, nI sitsa' yā'suk·.
It is under a stone, stlapalwitl tE smänt.
It is by a stone, splēEk tE smänt.
It is on a stone, tlatluk tE or nI tE smänt.
It is in the box, nE sinē'yû tE kō'akōa.
Near me, s'tEtEs tl'e'nsa.
A stone will sink in water, tE smänt t'pIl nI tE k·a.
In, on, nI.
Come with me, mē'tla skâ tl'e'nsa.
Come home with me, mē'tla tāk·Q skâ tl'e'nsa.
I will go with you, nEm-tsEn-tca skā tl'nō'a.
Let us build a house, ē-tla-sē-autQEm.
Let us make a canoe, ē-tla-häi.
Let us go there, ē-tla-nEm tE nI.
Let us eat it, ē-tla-nEpi'tl.
The canoe floats on the water, s'pEpākQ tE snu'kQEtl.
The moon is bright, stä'tû tE tl'kElts.
The day is clear, cwä'Ek·Q.
It is cloudy, cuē'EstEn.
He is making a fire, ē-hai'Ekwelsip.
Give me the horse, mē's-tcûQ tE st'kaiū.
I can ride, sō'wa-tsEn kwEnEs si tsā.
I can swim, sō'wa-tsEn kwEnEs t'I'sEm.
Are you cold? ē-ā'-tcûQ tsa'tsalEm?
I am cold, ē'-tsEn tsa'tsatlEm, *or* simply ē'-tsEn, I am.
Are you hungry? ē-ā'-tcûQ kwā'kwē?
Is he sick? ē-ā'-kā'käi?
Is your father dead? n'-ē-ā'-k'ai kwaä'n mEn?
Is he coming? ā-mē tsa?
Are you coming? ā-mē'-tcûQ tsa.
I often go there, wIā'tl kwEnEs wa-hen-nEm tsa.
Go in, kwatQē'lEm! Come in, mē-kwatQē'lEm.
Did you shoot a deer? n'-ē-ā'-tcûQ kwiliç tE smēis?
Is it dark? yetl s'sets?
It is light (in answer to question), I stä'tū.
I want you to go, nEstlē kwa E's-nEm. Come along! mē tla.
It is Harry, tla Harry. It is Mary, tla Mary.
Once he came to my house, nE'tsauQitl ks' ämēs tEnE lā'lem.
He often used to come, wIyā's-E-tl k's-ämēs.
When I came in the man was lying on the bed, tlâ's-wā ā'qEs tE swē'Els I'-ē-tsEn-mē kwatQē'lEm.

When I went out I saw him there, ĕ'-tsEn-kwä'ts-nūQ kwEnEs nū'witl nEm k·El.

I am hurt, ĕ'-tsEn-mäqtl.

You have hurt me, ē-tcūQ-mäqtl namiH

Who made this? tôwet slai's tE I'? (*verbatim*, Whose work is this?)

I did, tE ensa (if alone with questioner the answer would then be simply ens); E ensa ' is the selective form of this pronoun.

He did, tla t'sä' (*verbatim*, it is that one).

He has killed it, nI-kai't-nūQ-Es.

I should like some water, nE-stlē kwa k·ā.

I should like to have a horse, nE-stlē kwa st'kaiū.

He said he was going, Huta kwEs nEms.

I said I was going, Huta-tsEn kwEns nEm.

He said I was a bad man, Huta kwEnEs k·El (mistē'ūQ).

He said I ought to go, Huta wa-nEm-En.

I told him he ought to go, nē-tsEn-Hut-Es-tōQ-wa-tläs-nEm.

When you come in, shut the door, t'kai-tcūQ sHetl wa-mē-ōQ kwatQē'lEm.

When you are sick you should take medicine, talmō'Hse-tcūQ wā (or etl) ikau'ōQ.

When the deer saw me it ran away, nI tlō tE smēis kwEs nI's kwäts nEmsHEs.

When it rains I stay in the house, wiskata'uQ-tsEn-al etl stlEmoQEs.

Would you not like some meat? auā-ā' stlēs kwa smē'is?

I must drink, k·ākut ensa.

I ought to drink, stlo'tlun kwEns k·ā'ka.

I am eating meat, ē'tltEn-tsEn tE smē'is.

Which is your horse? tla kwa ne'tsa Es st'kai'ū?

He stole my horse, nI-käEns-Es kw'sEn'-st'kai'ū.

He stole your horse, nI-käEns-Em kw'sEs-st'kai'ū.

He killed my dog, nI-kai'EtEs kw'sEn'-skwomai'.

He killed your dog, nI-kai'EtEs kw's-Es-skwomai'.

I lost my dog, nē-tsEn-Ekwā'nEm kw'sEn' skwomai'.

He lost his dog, nI Ekwā'nem kw's skwomai'.

I cut my foot (indefinite of meāns), tlits-Hin.

It is raining, stlEmō'Q.

It rained yesterday, stlEmōQ-etl tsila'katlitl.

It will rain to-morrow, stlEmōQ-tsa wai'yilis.

If it rains I shall not go, hātsā tlEmōQ ē-au'a-tsEn nEm-En.

If it is fine to-morrow we will go hunting, hātsā ē-wE wāi'yilis nE'm-tst hä'wa (*or* pEplā'tl if with a gun).

Where are you? nè-tcūQ anI'tsa? ē-'tsEn ō tE nā, I am here; *or* ē kwE nā (the latter is an older form).

I live here, ē-tsEn-tlenauQ ē kwE nā (in answer to question).

I live there, nE-tsEn nI' kwe nI (in answer to question).

He is in the house, nI s'Hatau'Q (with emphasis on *in* it would be nI yū s' Hata'uQ.

He is on the beach, nI tsā'tsō.

I am a Kwā'ntlEn, Kwā'ntlEn-tsEn.

I shoot, Qolic-tsen; I am shooting, ē-Qolic-tsEn; to shoot, s-Qolic; he shoots, nI-Qolic; a shooter, ä-QolQolic *or* nūks-Qolic.

I fish, tlätlEs-tsEn; I am fishing, ē-tsEn-tlätlEs; to fish, stlätlEs = fishing; he fishes, nI tlätlEs; a fisher, nūks-tlas.

I hunt, hä'wa-tsEn; I am hunting, ē-'tsEn hä'wa; he hunts, nI hä'wa; a hunter, nūks-hä'wa.

I dig, sē'kwEls-tsEn; I am digging, ē-'tsEn-sē'Ekwels; to dig, sē'kwEls; he digs, nI sē'kwEls; a digger, nūks-sē'kwEls, or Hsēsēkwels.

I work, yäas-tsEn; I am working, ē-tsEn-yäas; to work, syäas; he works, nI yaEs; a worker, nūks-yäas or nūkc-läas.

I swim, tētsEm-tsEn; I am swimming, ē-tsEn-tētsEm; to swim, stētsEm; he swims, nI tetsEm; a swimmer, nūks-tētsEm.

I run, Hunyhä'nEm-tsEn; I am running, ē-tsEn-Hunyhä'nEm; he runs, nI Hunyhä'nEm; to run, sHunyhä'nEm; a runner, nūks-Hunyhä'nEm.

I dance, kwaiē'litl-tsEn; I am dancing, ē-tsEn-kwaiē'litl; to dance, skwaiē'litl; he dances, nI kwaiē'litl; a dancer, nūks-kwaiē'litl. [This terminal *tl* has sometimes the sound of H.]

A canoe maker, nūks-häi.
A basket maker, nūks-kwä wEç (skwäwEç = to pierce).
one stone, nEtsa smänt.
two stones, yisē'la smänt.
many stones, kuq smänt.
any stones, kō-smänt-äl.
few stones, k·'amas smänt.
all stones, mōk smänt.
some stones, smEmä'nt.
no stones, au'ita smänt.
one dog, nE'tsa skwomai'.
two dogs, yisē'la ,,
many dogs, kuq ,,
any dogs, kō-skwomai'-äl.
few dogs, kē'kamas skwomai'.
all dogs, mōk. ,,
some dogs, skwomkwomai'.
no dogs, au'ita skwomai'.
one hat, nE'tsa yä'suk or ye'tsawok
two hats, yisē'la ,, or yisi'lawok.
many hats, kuqEwok.
few hats, kē'kamas yä'suk.
all hats, mōk ,,
no hats, au'ita ,,
this house, tE-na lā'lEm.
these houses, tE-na Elā'lEm.
that house, tE-nI lā'lEm.
those houses, t'sa Elā'lEm.
these two houses, tE-I yisElā'lEm (I = here).
those ,, ,, t'sa ,,
this hat, tE-na yä'suk·.
these hats, tE-na yayä'suk·.
that hat, tE-nI yä'suk.
those hats, yē'sa or yI'sa yä'suk.
(The collective of this term is here differently formed from that in the Tcil'Qē'uk.)
right eye, cwIyä'lEs or s'wäiyä'lEs.
left eye, cEkwä'lEs or sEkwä'lEs.
both eyes, cwai'yälEs, or s'wai'yalEs, or kEq-ē'lum.
right hand, s'ēyūs.
left hand, s'Ekwaiyūs.
both hands, t'säyūs.
right foot, s'ēHin or s'aiHin.
left foot, sk·ōHin.
both feet, s'aiHin or s'q'HE'na.
right ear, cwIä'lä.
left ear, skâ'lä.
both ears, kwēn, kēn, or kwEnkwēn.

tEn Kwa'ntlEn, I am a descendant of the Kwa'ntlEn, or I belong to the Kwa'ntlEn by descent.

CONTINUOUS NATIVE TEXT IN NARRATIVE FORM.

TE Si'yis[1] tla swē'wolus.

(The Story of the Young-man.)

Nō'nsa	swē'Eka	yā'yEs tE	sä'ltEn.	ē'-tlās-wä	skwä'tsa	TE nE'tsa.	ē'-tlās-wä
a	man	was-engaged-in	fishing.	And-then	he-caught	one.	Then

kEla't	k'äm.	Qon-qātä'tsa	ē'-wE-tl-tslä'mätEs	kwä	Hä'pEs.
again	he dips (the bag-net).	While-so-doing	he-heard	a	whistling-noise.

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[1] *Si'yis* is the name given by the Kwa'ntlEn to stories they believe to be true, in contradistinction to the term *sōqwiä'm*, which signifies a 'fable' or 'myth.'

ē'-tlās-wä QElā'amEtEs. Tō-hī's-tsa k's-qē'liHs. ē'tlō kEla't k'äm Tlō kEla't
Then he listens. Awhile he-stands. Then again he-dips. Then again

tslä'mätEs kwä Hä'pEs. ē'-tlō kEla't k'äm. Tlō kEla't talä'mätEs kwä
he-hears a whistling-noise. Then again he-dips. Then again he hears a

Hä'pEs. ē'-tlās-wä sqē'liHs kwä tōhī's. KEla't tslä'mätEs kwä
whistling-noise. And-then he-stands a little-time. Again he hears a

Hä'pEs. ē'-tlās-wä tulnuQs k's-tlas tE cqEnsEs[1] nī-Hä'HapEs.
whistling-noise. Then he-knew that-it-was the killed-thing had-been-whistling.

Tlās-wä kwe'nits tE swe'ltens. ē'-tlās-wä lum-lu'mits. ē'-tlās-wä nEms tāk·Q.
Then he-took the net-his. Then he-folded-it-up. Then he-went home.

ē'-tlās-wä QunnI'ns tE cōwä'lis. ē'-tlās-wä kwäls: 'nEm-tsEn ē-yilisä'la.
Then he-reached the parents-his. Then he said: 'Going-I am away.

Tōhī's-tsa ē'-mē-tsEn k'onsit.' ē'-tlās-Es-wä kwenits tE ämī'mEn slē'uk·Q.
In-a-little-while coming-I am back.' And then he-took a little food.

ē'-tlās-wä nEms. ē'-tlās-Es-wä kwaii'sEts.
Then he went. And then he-underwent-his-training-for-a-'medicine'-man.

Wä'tl-tsa k's-wa-ē'-stauQs tE sEyē'l tE cāqEs tE mE'nas. HäHä'sEn
Always they-kept-ready the parents the bed-his the son-theirs. Fourth

tl'kElts ē-mē QEä'met. kw'sEs—tsa mä-tlā-mē tāk·Q ē'-tlās-Es-wä
moon he-came home. While was-coming home then

kwe'nits tE sä'kum ē'-tlās-Es-wä tlā'kuts nē tE kwE'lEs. ē'-tlās-Es-wä
he-took the cedar-bark and then he-put-it on the stomach-his. Then

kē'kuts tE kwE'lEs. snät tsa kwa k's-wE-tl-tä'tcEls QEä'met.
he-bound-up the stomach-his. Night it will be when-he-gets home.

ē'-wä-cwEwī' sE sī'El. ē'-tlās-Es-wä Qēts tE swē'akus. ē'-tlās-Es-wä
She-was-awake the mother. Then she-woke the husband. Then

p'tä'mits: 'Nōä'?' 'Ensa.' ē'tlās-Es-wä nEms nä'mistQEs
they ask: 'Is-that-you?' 'Yes, it is I.' Then they go they-take-him-to

tE ca'qEs. ēts kwa mē tōhī's ē'-mē-k'ap tE
the bed-his. When a little time has passed assemble-together the

keq mistē'uQ. ē'-tlās-Es-wä kwE'lEs tE sIyä'lakwa: 'Tauhauwä'lEmatla
lots-of people. Then spoke the old-people: 'Let-us-see-you-perform

swā'wolus.' ē'-tlās-wä sqē'liHs tE swā'wolus. ē'-tlās-wä hauwä'lEms.
young-men.' Then they-stood-up the young-men. Then they perform.

ē'-tlās-wä kwE'lEs-tsa swē'wolus: 'Tō-yū'ktatla!' ē'-tlās-wä kwE'lEs
Then he-said young-man: 'Let the fire be made up!' Then said

tE sIyä'lakwa: 'Yūkta'tla, I-ē-tst-wa kwa tEtE-a'n.' ē'-tlās-wä
the old-people: 'Build-up-the-fire, we are going to have some wonder.' Then

mēs sqē'liH. ē'-tlās-wä kwE'lEs: 'NEmä'tla kwe'nit kwa sçu'ma.'
he-came he-stood-up. Then he-said: 'Go fetch a big-cedar-kettle.'

ē'-tlās-wä nEm tE swā'wolus kwe'nitEs tE sçuma. ē'-tlās-wä
Then they went the young-men they-got the big-cedar-kettle. Then

QEē'nQEs; tla'katEs stE'tEs tE hai'yuk. ē'-tlās-wä nEms tō-tla ē'-tlās-we-tl
they-brought-it; they-put-it near the fire. Then went he and began

kwaiyē'leHs nē tE sçuma. Tōhī's-tsa ks' kwaiyē'leHs. Tsultsulā'ntsa
to dance round-about the big-kettle. Awhile he danced. From-end-to-end

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[1] Anything that is killed in hunting, fishing, &c., is called the hunter's *sqEnsa* = 'prey,' 'spoil.'

kwaiyē'liHs. ē'-tlâs-Es-wä mēs wil tE k·a. ē'-wlā'tl tsa
(of the kettle) he danced. Then came to appear the water. Now continues
kwaiyēleHs tō-tla. ē'-tlas-Es-wa mēs wil tE so'k·wäi. ō-tlō kElä't mē
to dance he. Then came to appear a salmon. Yet again came
wil tE-tlō sō'k·wäi. ē'-tlâs-wä yissä'lis tE sō'k·wäi k's He'tEms nē
to appear another salmon. Then two the salmon they swam-about in
tE sçuma. Tōhī's k's qutEs-tsa. ē'-nē-tlō-nEm āl sōq.
the big-kettle. For awhile they continue. Then-all-again went and both disappeared.

Sōqwiä'm tla SmElō' ē SkElu'tsEmEs.

(The story of SmElō' and SkElu'tsEmEs.)

WE-nē-tsa¹-āl tE yai'sEla slEntlä'nI, syayä'tEn tsa¹ tau-tlā'lEm. ē-nē-tsa tE ma'mE-
There were two women, widows they were. There were children-
nEs; mok· tsa sEwē'Eka. nē-k·ai tE cūwä'lI-s nē'a [2] tE skē'luH.
their; both were men-children. Dead the fathers-their there that war.
stEä'tsa, cūkwai'ts tE ma'mEnEs tau-tlā'-lEm. kwEkwai'tEs tau-tlā'-lEm.
Therefore, train-they the children they. They-are being trained, they.
ē'-mI tsē'sEm, ē-k's-ēs-wE-tl-sI'-sât sEwē'Eka tau-tlā'-lEm. ē'tlâs-wä
They come to grow-up, and when they big-become men they. Then
tla'lEms-āl kwâkwaii'sEt ē'tlâs-wä mē kwā'lEm-
they both underwent-their-training-for-'medicine-men'; and-then came strengths
kwom (from kwâmkwom, strength, power) sEt tau-tlā'-lEm. QEn-stEä'-tsa
(physical) become-strong they. Thereupon
ē'-wE-tl-näm EtsnA'mEt tE Kauē'tcin. k's-I's mē
it-spread-abroad (the report) heard the Kauē'tcin-(tribe). After-a-little-while
Hā'laHa [3] sEwē'Eka tau-tlā'-lEm. tE skwIç-s tau-tlā'-lEm
came the wonder-working powers (of) men those. The name-their they
SmElō' tE si'ntla, SkElu'tsEmEs tE sā'suk·. ē'-tlâs-Es-wä amē' tE Kauē'tcin
SmElō' the elder, SkElu'tsEmEs the younger. And-then came the Kauē'tcin-
snukQEtl.[4] Tâq-wE-nē tE tsō'tsō.[5] Tau-tlā-lEm
people in-war-canoes-to-fight. They are just-off the shore. They (the brothers)
âlE'qtEs tE skwai'tsI. ē-wlā'ç-tsa k's-wä-kwinä'ts tE kwā'kwEstEn-s [6]
they are searching for sea-urchins. Always they carried the clubs-their
tau-tlā-lEm. QEn-Hu'ta-tsa ē'-wE-tl-mē tä'tsEl te Kauē'tcin. ē'-tlâs-wä
they. While-thus-engaged they-came to arrive the Kauē'tcin. Then
ts'kwäts te saiyI'El ē'-tlâs-wä kwēs tau-tla-lEm näm
saw-them the mothers (the Kauē'tcin). Then climb they (the mothers) they go
tE s'tl'tla'el-tōQ ē'tlâs-wä t'HenEms [7] tau-tlā'-lEm ē'tlâs-wä
the roof. Then they-step-round rapidly they (the mothers) and then
ts'kwäts tE Kauē'tcin, mē sQtEä'won tE Kauē'tcin k's-tlâs SmElō' ē
see-them the Kauē'tcin, came the-thought to the Kaue'tcin that-it was SmElō' and
SkElu'tsEmEs. nē-wE-tl-kwats-nuq-Es tau-tlā'-lEm Kauē'tcin tE yai'sEla sEwē'Eka
SkElu'tsEmEs. They-had-seen-them (had) those Kauē'tcin the two men
Elatl tE snukQEtl. ē'-tlâs-wä sQtEä'wons tau-tlā-lEm k's tlâs skwaiē'ts tla SmElo'
in the cause. And-then they-thought they they-were slaves of SmElo'
ē SkElu'tsEmEs. ē'-tlâs-Es-wä mē kwElkwā'lEwon tau-tlā'-lEm
and SkElu'tsEmEs. And then came the thought (to) them (the Kauē'tcin)
k's-Is-k's-au'Es nä'mEs tlEl. ē'tlâs-wä kwE'nEtEm āl tE SmElō' ē tE
that-they-would-not go ashore. So then they seized both SmElō' and

SkElu'tsEmEs. ē'-tlās-wä kwE'nEts tE k·E'liHtens
SkElu'tsEmEs. And then they (the brothers) took the canoe-mats-their
nI-cwElākQ tE kwākwEstEns tau-tlā-lEm. nē-tsa tE nE'tsa
they were rolled-up-around the clubs-their they. There was (in) one
snukQEtl tE SmElō' nI tE tlō*-nE'tsa snukQEtl tE SkElu'tsEmEs. ē-'tlās-wä näm
canoe SmElō' in the other canoe SkElu'tsEmEs. And then they went
kā'nçEt. au'a wEnō'nEs näm Q'sākQ ē'-wE-tl kwä'tsätEm tl' SkElu'tsEmEs
back. Not much go far when he-looks-significantly- at SkElu'tsEmEs
tE çēyEçs, ē'-tlās-wä Qlalā'lists ē'-tlās-wä kwE'nEts
the elder-brother-his. And-then he-made-signs-with-his-eyes. And-then they took
te kwākwEstEns ē'tlās-wE-tl tlās-āl Hē'lEHs wEnon wä kwāmkwom tau-tlā'-lEm
the clubs-their and then they both fought much was strength (of) them
cwElā'Qa tau-tlā'-lEm, ē'-tlās-wä Qē mok· wetQ nE'tsa āl tE
quick-leapers they. And then they destroy all except one alone
kwätEs tau-tlā-'lEm. ē'-tlās-wä mē tāk·Q. ē'tlās-wä wlāç
they spare him they. Then they come home (the brothers). And then often
wE-kwākwaii'sEt. tūqa hutas tsa. ē'tlās-wä
they-train-as-medicine-men. A few times this (incident) is repeated. And then once
kElats amē tE Kauē'tcin. neu-tl'-tEluQEs tau-tlā'-lEm k's au'Es tlās SmElō' ē
again came the Kauē'tcin. They knew they were-not SmElō' and
SkElu'tsEmEs yIsä tluk tE Henem. ē'-tlās-wä mē tä'tcEl tau-tlā'lEm
SkElu'tsEmEs those doing the dancing (on the roof). And then came back those
Kauē'tcin. tlō tl' kEla't tE He'nEm tau-tlā'-lEm säyI'El. ē'tlās-wä kwEnkwE'nEtEm
Kauē'tcin. Then again the dancing those mothers. And then they took
kEla't tE SmElō' ē tE SkElu'tsEmEs. ē'-tlās-wä kwEnkwEnEtEm tE kE'liHtEns skā
again SmElō' and SkElu'tsEmEs. And then they took (also) the canoe-mats with
tE kwākwEstEn. tlās-Is'-wä-näm kwE'n-kwEn tau-tlā'-lEm SmElō' ē SkElu'tsEmEs
the clubs. And they went captives those SmElō' and SkElu'tsEmEs.
tlās-wä tEs tE lä'lEms tau-tlā'-lEm Kauē'tcin. ē'-tlās-wä nōQHEm tE
Then they got to the homes-of those Kauē'tcin. And then they put
SmElō' nI tE kwā'kẘa tlauq-tā'stEm tE SkElu'tsEmEs ē-tlās-wä
SmElō' in a box, they did the same to SkElu'tsEmEs. And then
sEnē'ūs kwa-hI's.[10] Näm tsa kEq swē'yi ē-tā'mEtEm :
they were boxed-up a-long-time. There went by many days they call-out :
'SmElō' !' 'Nā'u !' 'SkElu'tsEmEs !' 'Nā'u !' tlō tl'
'SmElō' !' 'Yes !' (he replies). 'SkElu'tsEmEs !' Yes ! (he replies). Then
kEla't tä'mEtEm : 'SmElō' !' 'Nā'u !'
again they call out : 'SmElō' !' 'Yes !' (he answers in a strong voice).
'SkElu'tsEmEs !' 'Nā'u !' Näm ō-kEq swē'yil. KEla't
'SkElu'tsEmEs !' 'Yes !' (he feebly replies). Go-by many days. Again
tä'mEtEm : 'SmElō' !' 'Nā'u !' 'SkElu tsEmEs !'
they call out : 'SmElō' !' 'Yes ! (he replies in a strong voice). 'SkElu'tsEmEs !'
'Nā'u !' skwā'lūens tau-tlā' lEm Kauē'tcin k's nIs wE-tl
'Yes !' (he feebly replies). They think them the Kauē'tcin that they are
kēakElā'msEt. ē'-tlās-wä kwEls tE Slä'm ō k's k pu sEt
growing very weak. And then spoke the chief : 'Good it is to come together
tE mok· Kauē'tcin nē'a tE nE'tsa lä'lEm' ē'-tlās-wä mē'·kup mok·
the all Kauē'tcin there (in) one house.' And then come-together all
te Kauē'tcin mok· kwEnä'lsEm tau-tlā'lEm. ē'-tlās-wä mō HeqtEm
the Kauē'tcin all bearing-arms they And then came to get up

tau-tlā-lEm. SmElō' ē SkElu'tsEmEs tau-tlā-lEm. ē-'tlās-wä haiyū'stEm
they SmElō' and SkElu'tsEmEs they. And then they decorated

tau-tlā'-lEm. stlēs tau-tlā'-lEm Kauē'tcin k's kwaiē'liHs tau-tlā'-lEm.
them. They desire they the Kauē'tcin that they should dance they.

ē'tlās-wä nEämEstō'Qs tE seu'wens tau-tlā -lEm. tlās-wä sHē'liHs SmElō'.
And then commenced the song-theirs they. Then he stood up SmElō'.

Tō-hīs k's-skwā'is k's-sHē'liHs tE SkElu'tsEmEs. ē'tlās-wä kwaiē'liHs
For-a-little-while he was-unable to stand (was) SkElu'tsEmEs. And then danced

tE SmElō'. tō-hī's k's-kwaiē'liHs. ē'-yE-tl sHē'liHs-nā'mits tE
SmElō'. Awhile he danced. And after that he-stood-up-by-himself (did)

SkElu'tsEmEs. ē'-tlās-wä kwaiē'liHs kwEnā'tEl. wä-ē-tsa-āl k's-mēs yE
SkElu'tsEmEs. And then danced they both-together. And then came gradually the

kwā'mkwomsEt tau-tlā'-lEm. tlās-wä kwEls tE siā'ms tE Kauē'tcin:
strength-of them. Then spake the chief-of the Kauē'tcin:

'QElalā'mtaça!' Tla'tlnksEm tau-tlā'lEm
'Listen to what they are saying!' Beating-time-with-their-hands (were) they

Kauē'tcin. Tlās-wä QElalā'ms tau-tlā'-lEm. tlās-wä tElōkwEs tE seu'wen
the Kauē'tcin. Then they-listen-to them. Then they understood the song

tla SmElō'. Hutä' kwEnnā' tE skwā'kwEls tE seu'wens tau-tlā'lEm: 'wäqausō'yEn
of SmElō'. It said these words the songs-of them: 'A-new-net

kwEnā s'kwā tlEsält ē-wä-kwEnālākEn-tsEn-tsa' ē-tlās-wä sä'nEmps tE siā'm
barrier if-spread-over get over-it I will.' And then he-orders the chief

ē-k's-amēs kwä'tlatEm k's sweltEn. tlās-wä mē q'tāstEm tE sweltEn
that they should-come to spread a net. Then they come bearing a net.

Tō-hī's skwaiē'liHs tau-tlā'-lEm. ē'-yE-tls Qlalā'is
Awhile they dance-on they. And presently he makes signs with his eye to

tE cē'yEtls. ē'tlāswä s'tlEmps tau'-tlā'-lEm Qonä'm tE tcī'tcitl
the elder brother-his. And then jumped they up to the top (of the house)

tlās-wä Qē'ak·Q tau-tlā'-lEm. tlās-wä QonHänEn tau-tlā'-lEm
then they-were-caught-in-the-meshes-of-the-net they. Then run-round they

Kauē'tcin nam te tcī'tcitl ē'tlās-wä tlē'tsEtEm tl' SkElu'tsEmEs tE sQē'aQōks
the Kauē'tcin to-get-to the top. And then was cut by SkElu'tsEmEs the mesh.

ē'-tlās-wä kwa'sit hai tE SmElō' au'Eta tlē'ts'tEm stä'a tsa cūnī's-kai tE
And then he escaped, but did SmElō' no cutting therefore soon killed was

SmElō'.
SmElō'.

Explanatory Notes on Above.

[1] This term *tsa* used here and elsewhere in the story seems to have the force of a substantive verb. It is also found in conjunction with temporal adverbs. It is not improbable that it is the same with *tsa*, the sign of the future. It is seen also in the following phrases: näm-*tsa* = he is going; au'a-*tsa* = it is not.

[2] *nē'a* appears twice in the story. It is a relative or selective adverb of location, and appears to be a modified form of the common locative *nē*, the addition of *a* making it relate to some particular place or incident.

[3] *nā'laHa* or *qā'laqa* is the distributive form of *nāHa* or *qāqa*, 'to perform wonders It also forms the name of the great transformer of the Halkōmē'lEm tribes, who is called *QEQä'ls*, or simply *Qäls*. His name is therefore significant of his character, and means 'the wonder-working one.'

[4] In this expression *snu'kqEtl* does not signify a 'boat,' its common meaning, but 'to fight.' It is commonly used with this sense in Kwa'ntlEn. As the tribes of the island had to come in their canoes to wage war upon the river tribes, the coming of canoes generally meant fighting; hence the sense given to this term.

[5] *Tsō'tsō* is an adverb of location in a particular sense. It is used only to

indicate the position of an object situated in an open, clear ground. An animal out on an open stretch of land would be said to be *tso tso*, 'some way off,' also.

[6] Kwā'kwEstEns is an interesting compound. It is composed of the verbal stem kwākq, 'to strike,' the synthetic form for head, *Es*, which is taken from the independent form *skaiyEs*, the instrumental suffix *-tEn*, and the possessive sign *s* of the third person. It consequently signifies 'an instrument for breaking heads.' A weapon or club for striking the body generally is termed *kwā'kwottEn*, 'a striking instrument.'

[7] *t'E'cnEms* means literally 'to foot it.' It is not exactly dancing, but rather rapid movements from place to place. The rapid motions of the mothers on the roof misled the Kauē'tcin in thinking them to be SmElō' and SkElu'tsEmEs. It was not till they had repeatedly carried off the latter as slaves that they learned the mistake.

[8] *tE tlō nEtsa* = 'the other,' is literally 'the again one.'

[9] The reduplication of this term marks the *repetition* of the action. In the story as usually told by the Indians the coming of the Kauē'tcin and the taking of the two brothers as supposed slaves occurred several times. In the version here given this part is left out to save a tiresome repetition of the same phraseology.

[10] The comparison of this compound *kwa-hī's* with *tō-hī's* is interesting. The *kwa* here is the indefinite article which figures so largely in Salish syntax. Its presence here gives the sense of indefiniteness to the time which elapsed. When *hī's* is compounded with *tō* the opposite sense is conveyed. This *tō* is seen to enter into all sorts of compounds. It is the prefix in *tō-tla*, he, him, of which the plural form in *tau*-tlā'lEm plays so conspicuous a rôle in Kwa'ntlEn narrative. The same element is seen in the interrogative tō-wet? 'whose?' and in many other compounds.

FREE TRANSLATION OF ABOVE STORIES.

Story of the Magic Water and Salmon.

Once upon a time a young man went out fishing. In a little while he secured a fish. As he was dipping his bag-net to try his luck again, he heard a strange whistling kind of noise. He paused to listen. Presently he dipped his net again. As he did so he heard the same strange noise. Again he listened and tried to discover what it was, but at first could not. When he listened the sound ceased, but began again as soon as he dipped his net. After a while he discovered that the noise proceeded from the fish he had taken. He then knew that it was no common fish. He stopped his work at once, folded up his net, and went home. When he reached home he told his parents that he was going away for a time, but would come back again soon. His intention was to go away and train himself for a medicine-man. He took a little food with him and then set out. All the time that he was absent his parents kept his bed ready for him. After he had been away for four months he prepared to return home. While on the way he bound his stomach with cedar-bands to stay his hunger and support his frame, which was much attenuated by his long fast. It was night when he reached home. His mother, who was awake, heard him enter and awoke her husband. They called out to him and asked if it was he. He replied in the affirmative, and they at once got up and assisted him to his bed. When he had recovered his strength a large number of people came together to see him. When they had all assembled the elders said to the different young men present, 'Let us see you perform your magic feats.' The young men responded by getting up and going through their tricks. When they had finished the youth who had caught the strange fish said, 'Let the fire be made up.' The elders also added, 'Make up the fire; we are going to see him perform some great wonder.' The youth then came forward and asked the others to fetch a large kettle. They went for the utensil and presently returned with it and placed it near the fire. The youth then began his dance. He danced from end to end of the big kettle.

After a little time water was seen to be rising in the kettle. He continued to dance and presently a salmon appeared swimming in the water. A little later a second fish was seen swimming with the first. When this had continued for a little while he stopped his dancing and both fishes and water instantly disappeared.

Note.—We have here in this story the mythical account of the origin of the salmon su'līa or crest.

The Story of Smᴇlō' and Skᴇlu'tsᴇmᴇs.

There were once two women who were widows. They had lost their common husband in war. They each had a son about the same age. The elder was called Smᴇlo' and the younger Skᴇlu'tsᴇmᴇs. The mothers trained them very carefully while they were young. When they reached adolescence they underwent their *kwakwaii'sᴇt*, or training for medicine-men. They practised themselves in all bodily exercises and became both nimble of feet and strong of limb. In a little time their wonder-working powers came to them, and they could perform wonderful feats. One day they were off the shore in their canoe to hunt for sea-urchins. While they were thus engaged a war-party of Kauē'tcin drew near. They had heard of the powers of the two young shamans and had come to capture them. The mothers of the young men perceived the Kauē'tcin approaching and sought to deceive them into thinking they were themselves the two young men. They climbed to the roof of their dwelling and began running hither and thither in a rapid and bewildering fashion, and thus led the Kauē'tcin to believe them to be the young shamans. Seeing them thus prepared for them they would not land, but contented themselves with seizing Smᴇlō' and Skᴇlu'tsᴇmᴇs, whom they took to be slaves of the shamans, and placed them in separate canoes. When they were being seized each took up from the bottom of the canoe his canoe-mat, which was rolled up and contained his war club. The Kauē'tcin now made for home again. They had not gone far, however, when Skᴇlu'tsᴇmᴇs looked into his elder brother's eyes in a significant manner and signed to him to be ready. Each then suddenly seized his club and, leaping with nimble feet from one canoe to another, clubbed every one of the Kauē'tcin to death except one man. Him they spared. They then returned to shore and went through a further training. The Kauē'tcin came and did the same thing several times and were on each occasion overcome by the two shamans in the same manner. At last they discovered that the supposed slaves were really Smᴇlō' and Skᴇlu'tsᴇmᴇs. The next time they came they seized them as before, but took the precaution on this occasion to deprive them of their rolled mats containing their clubs. This placed the youths in the power of the Kauē'tcin, who took them home. But so fearful were they of their escaping and doing them harm that they shut them up in boxes and kept them fasting for several days. When they thought them subdued they called out to them by their names. Both responded in strong voices. The Kauē'tcin therefore left them to fast still longer. When a further period had gone by they called out to them again. Smᴇlō' still answered in a strong voice; but Skᴇlu'tsᴇmᴇs, perceiving their object, answered more feebly. They therefore thought they were growing weak. The chief of the Kauē'tcin then bade his people assemble together in one house. The boxes containing Smᴇlō' and Skᴇlu'tsᴇmᴇs were also brought in and opened and they were allowed to get out. The Kauē'tcin then decorated them and called upon them to dance. SmElō' complied and began his dance-song at once. SkElu'tsEmEs, still feigning to be weak and unable to stand, waited awhile. When a little time had passed he got up by himself and joined his brother in the dance. As they danced their strength came gradually back to them. They danced so well that all the Kauē'tcin applauded them and beat time for them with their hands, except the chief. He had been listening to SmElō''s song. He then called out to his people to listen to the words of the song. They did so, and heard the following words: 'You may spread your new nets as barriers to keep me in, but I will jump over them.' The chief thereupon bade them place a net on the outside of the smoke-hole. This they did. SmElō' and SkElu'tsEmEs still danced on; but presently the latter made signs to his elder brother with his eyes, and a moment later both made a jump through the roof. They were both caught in the meshes of the net. While the Kauē'tcin were running out to climb on the roof and secure them SkElu'tsEmEs took a small stone knife he had kept hidden under his arm and cut himself free and made his escape. SmElō', who was not so clever as his younger brother, was unable to disentangle himself from the meshes of the net and was again captured. This time they put him to death.

Principal Terms of Consanguinity and Affinity in the Kwa'ntlEn.

father, mEn.
mother, tEn; when addressed by her children she is called *tat*.
parents, cōwä'lI, sEyē'ls, sI'El, *or* saiyI'El.
These terms are applied to either parent indifferently in narration.
sē'la { grandfather.
 grandmother.
tsä'muk· { great-grandfather.
 great-grandmother.
ä'kwIyuk· { great-great-grandfather.
 ,, ,, grandmother.
ts''pIyuk· { great-great-great-grandfather.
 great-great-great-grandmother.
mE'na { son / daughter } or child.
ma'mEna { sons / daughters } or children.
si'ntla, eldest or first-born child.
'nQē'tsEn, middle ,, ,,
sä'suk· or sä'suk·t, youngest or last-born child.
cē'yEtl or çē'yEç { elder brother.
 ,, sister.
 ,, cousin.
sä'suk· { younger brother.
 ,, sister.
 ,, cousin.
ē'litl, brother, or sister, employed in such sentences as 'Where is your brother? or sister?
cQEmnē'kq { uncle (parent alive).
 aunt (,, ,,).
cQEmEsI'atl { uncle (parent dead).
 aunt (,, ,,).
sQEnma'itl, cousins (when parent is dead).
smä'tuktEn { sister-in-law.
 brother-in-law.
swä'kus, husband.
tcauQ, wife.
stcauQ, married man.
swä'wEkus, married woman.
The derivation of these two terms obvious.
syä'tEn or sI'atEn { widow.
 widower.
synyä'tEn { widows.
 widowers.
wä'nim, orphan.
lover, kle'tEl.

Principal Terms denoting Sex.

swē'Eka, man.
slēnI *or* tlēnē, woman.
swē'wolus, youth.
swä'wolus, youths.
k'ä'mI, maiden.
swē'Ekotl, boy.
k'ämIatl, girl.
slē'tkEtl, child.
skä'kEln, infant.

CORPOREAL TERMS.

arm, tä'lō.
back, slu'kawitl.
bone, s'am:
body, slEQē'ūs.
breasts of woman, sku'ma.

chest, s'ī'lus.
chin, slipai'ᴇsᴇn.

ear, k'wēn.
elbow, skwomsä'lākᴇn.
eye, k·u'lum.
eyebrow, sâ'mᴇn.
eyelashes, tli'ptᴇn.
eye, pupil of, kēʜâ'lis.

face, s'ä'çus.
finger, slu'ʜtcis.
1st finger, metsumin (= pointer).
2nd finger, sᴇɴꞯɪ'tcintcis (= middle one).
little finger, sâsauk·tä'ltcis (= youngest or smallest finger).
foot (and lower leg), sq'una.
foot (alone), snu'kꞯolcin.
forehead, s'kwomᴇl.[1]

head, skai'yus.
head, crown of, skai'ᴇluk·.
head, side of, sꞯē'ᴇlcna.
head, back of, tᴇ'psum.
hair of head, mā'kᴇn.
hair on face, kwē'nɪᴇsᴇn.[2]
hair of body, kwē'nus.
hair of animals, sâ'i.
hand, tcälic.

heart, tsä'la.

jaw, sumqai'sᴇn.

knee, sk'pâ'lsitᴇn.

leg (lower), sk·ōsu'mcin.
lip (upper), slâ'isᴇn.
lip (lower), slipai'ᴇsᴇn.

mouth, sā'sin.
milk of the breast, sku'ma.

nail (finger), k·ō'ltcis.
neck, tpsum.
nose, mu'ksᴇn.[3]

skin, kwᴇ'lû (human).
skin, kwᴇ'lû (animal).[4]
shoulder, kwo'ktᴇn.
stomach, k'wᴇ'la.

thigh, spitē'lip.
throat, e'ltlitl or e'lçitl.
thumb, mōkwamu'ltcis (= stumpy finger).
toe, slu'kcin.
toe-nail, k·ō'lcin.
tongue, to'qsetl.
tooth, ye'nis.

Animals, Birds, and Fish.

animal (generic), tᴇtsa'lᴇmôꞯ.
ant, tse'metsa.

bat, kwokwillā'kᴇn.
bear (black), spâs.
bear (grizzly), kwēi'tsᴇn.
bear (brown), kwē'itsᴇn.
beaver, skᴇlau'.
bee (bumble), kwo'ma.
bee (small wild), sᴇsɪm'oiya.
bird (generic), mauꞯ *or* mōꞯ.
butterfly (generic), smemē'yetl.

crane, smō'kwa.
chipmunk, q'pa'tsᴇn (name has reference to stripe on the back).

deer, smēis or t'lilktᴇnᴀ = ('long ears').
dog, skwomai'.
duck (mallard), tᴇ'nᴇksum.
eagle, yō'kꞯila.

elk, kai'yēts.

fish, tsā'qōal.
flee, tata'tlᴇm.
frog, ꞯō'kas.

goose (black), ē'qa.

hawk (fish), tsē'ꞯtsauq.
hawk (chicken), ʜumbē'mels.
horse, st"kaiû.
housefly, ꞯōkwaiyī'ya.

jay, sꞯɪ'sits.

kingfisher, sᴇtci'la.

lizard, pē'tyᴇn.
louse, mitʜsᴇn.

mosquito, kwai'an.
mouse, kwā'tᴇn.

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[1] A man with a prominent bulging forehead was called s'kwo'mtlis.

[2] There are no terms in this dialect corresponding to 'beard,' 'whiskers,' 'mustache.'

[3] According to my informants the Kwa'ntlᴇn do not possess terms for 'bridge of nose,' 'septum,' &c.

[4] The Kwa'ntlᴇn do not differentiate between the skin of themselves and that of animals as do the Sk·qō'mic.

mountain-goat, p'lkE'lken.
mountain-lion, cougar, sQō'wa.

otter, skā'tla.
owl, tci''muH.

pigeon, hāmā'.

rabbit, sku'kauwes.
raccoon, mu'lis.
rat, haut.
robin, s'kō'kāt.

salmon ('spring'): swā'k·um, earlier and smaller kind; sElahā'tl, later and larger ones.
salmon ('sock-eye'), su'kāi.
salmon ('steel-head'), kē'ūq.
salmon ('cohoe'), kō'kwEs.
salmon ('dog'), kwā'lū.
skunk, spEpatsī'n.
snake, e'tlkai.
snipe, skais.
spider (generic), kEskE'sin.
swan, cQō'akEn.

toad, pī'pom.

weasel, sElslEm.
wild-cat, skūtsçā'mis.
wolf, s't'kai'ya.
woodpecker (large red-headed), tEmE-tlsE'psum.
woodpecker (medium-sized), tsē'kut.
woodpecker (small), tsā'tum.
wren, tä'mla.

TABLE OF GENERAL TERMS.

above, tcī'tcitl.
afternoon, hai tE tuk swē'il = (done *or* gone the noon).
all, mok·.
anybody, we't-al.
arrow, skwEla's.
ashes, cle'ltEn.
autumn, tEm hēlā'noQ = (time of no growth).

bad, kEl.
bailer, tle'ltEn.
bark, pE'līyus.
beach, tsā'tsō.
beat (to), s'kōkwa'ls.
beautiful (*formosus*), ēē'mut.
beautiful (*pulcher*), yā'mic.
bed, cwā'Hus.
below, tlītlEp.
berries, ts'sīm.
big, sī *or* tsī.
bitter, sâqum.
black, skē'Eq.
blanket (native), swo'kwatl. (small kind), stōmōkisatl (large kind).
blanket (imported), pEk kulō'wit.
blue, tsātsaQom.
bow, tō'qûats.
box, kōa'ka.
boy, swē'Ektl.
branch, tsēHtatcis.
bright, stē'wil.
broad, tl'ket.
brook, stä'tlō = little river.
bud, pe'ksum.
bog, mâk·ūm = (mossy).

camp, ku'lum.
canoe, smukwitl *or* smuQitl.
chief, sīā'm.
child, slē'tkEtl.
cinders, pē'tsut.
cliff, tcī'tlis.
cloud, s'wā'sitEn.
cold, haitl.
crooked, spai'pī.

damp, sä'stsum,
dark, set.
day, swē'yil *or* swē'il.
daybreak, ta'wil.
dead, k·ai.
death, sk·ai.
doctor = (healer), tlitlawinok.
door, stu'ktEn = (curtain).
down (of birds), stlpE'lkEn.
dry, tsē'ūq.

earth, tEmu'H.
east, *vaoat*.
eddy, kai'akum.
evening, Qunä'nt.

far, tsāQ.
fat (man), nīl.
fat (animal), nos.
feather, cElts.
few, EHwī'n.
fight (to), skwē'ltEn.
fire, hä'yūk.
fire-place, cwēkâil.
firewood, slā'tl.
flame, kwä'taQom.
flat, luku'nEp.
flesh, slē'ūk.
flower, sp'E'kum.
foam, spā'k·ōm.
fog, skE'tyhum.
foggy, skä'tyhum.
full moon, sk·ukē'its.

garden, kwāqt (borrowed from the Kētsi tribe).
ghost, spElkwē'ts.
girl, k'amla'tl.
good, ē.

good-bye, Haiā wEtl.
green, s'hä'i.

hail, skwilkwa'lōH = (pellets).
happy, hē'lūk.
hard, k'lōH.
here, ē, kwE-nI.
hill, skā'kwEp.
hollow, cwä'tkwâwon.
home [1] tāk·Q, QEā'met.
horn, tse'stEn.
hot, kōā'kōas.
house, home, lā'lEm.

ice, splū'.
ill, s'Il.
Indian, Qo'l'mūQ.
infant, skā'kEla.
island, tl'säs.

kick (to), slemäe'ls.
kind, Qē'QEtl.
knife, tle'tstEn.

lake, Hä'tsa.
lamplight, häyūkwē n.
large, sI *or* tsI.
laugh, snē'Em.
leaf, tsā'tla.
lean, skwomō'H.
life, cQE'lI.
light, stē'wil.
lightning, squ'nok·t = (flashing of the eyes of the thunder-bird).
little, amē'mEn.
long, tlā'kut.
loud, skē'lekup.

maiden, k'a'mi.
man, swē'Eka.
man (old), clä'lakwa (tE swē'Eka),
man (married), stcauQ.
many, much, kuq *or* kEq.
meat, smē'is *or* smēs.
moon, tl'kElts.
morning, nEtitl.
mountain, smä'Enit.
mud, s'ē'kEl.

narrow, tiē'tq.
near, st'tEs.
needle, pe'tstEn.
night, snet.
no, au'a.
nobody, aui'ta-wet.
none, aui'ta.
noon, tuk-swē'il
north, tē'wot.
now, tEnā'.

paddle, sk·u'mEl.
people, elQ'lEmuQ.
person, mistēūQ.

quick, Qom (intensive form Q·mQom).
quiet, sI'batl.
quiver, tsilqElstEn.

rain, tlumōH.
red, skwIm.
river, stä'lō = (flowing water).
rock, smänt.
rotten, tsatsa'kwom.
rough, slens
round, se'ltsum.

sad, stēl, *or* stEē'l.
saw, clI'tläsets.
scissors, sä'mkelts = (to chip).
sea, kwä'tlkwa.
seer, seu'a *or* seu'wa.
shaman, sQEnä'm *or* cwEnā'Em.
short, tsutsI'tl.
sick, kä'käi.
sit (to), sä'mut.
sky, swēil *or* swaiyil.
slow, ai'yum.
small, amē'mEn.
smile, sQnē'yamus.
smoke, spo'tlEm.
snow (to), yē'yuk; snow, mā'ka; syē'yuk, it is snowing.
soft (to the touch), nē'akwom.
,, (easy to break), kē'aka.
soot, kwâlsEp.
south, yIH.
sour, tä'tsum.
spirit, soul, smistē'uQ.
spring, tEm kwē'lis = (uncovering time).
star, kōā'sEn.
stand (to), sqē'litl.
stone, smänt.
stream, stä'tlō = little river.
straight, suk·.
strength, Eyu'm.
strike (to), skwā'kwot.
strong, kwo'mkwum.
summer, tEm kwā'lakwEs (sun season).
sunset, tsōH.
sun, slā'kwum.
swamp, tsē'tsakel.
sweet, kä'tum.

that, tE-nI, t'sa.
the, tE (masc.), sE (fem.)
these, tE-nā.
there, nI *or* nē, kwE-nā'.
thick, p'tlet.

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[1] The distinction in meaning between these two terms is interesting. *tāke* is always employed by speaker when referring to his home when he is absent from it; QEā'met when he arrives there. See use of these terms in story in Kwa'ntlEn text.

thin, skwomō'H.
this, tE-nā, tI.
those, tE-nI, t'sū-lI.
thunder, sQo'kQas.
tobacco, spo'tlEm.
to-day, tE nā wai'yil = (this day).
to-morrow, wai'yilis.
torchlight, skwe'ncen.
tree, sk'ā'it.
twilight, set-til.

ugly, kElē'mut (said of persons).
,, kElkElmut (said ot animals).
unkind, HkEla'QEtl.

village, *vacat*.

warrior, Q'skukē'letl.
wash (to), tsōq.
water, k·a.
weak, kē'k·Elam.
weasel, sElslE'm.
west, *vacat*.
wet, tlok·.
which? kwa nE'tsa?
verbatim, a one.
white, pEk.
who? wet?
whose? tōwet?
wind, s'pEhe'ls.
window, skwatcā'stEn.
winter, tEm Haitl = (cold season).
witch, sewē'n *or* seūwē'n.
wood, siā'tl.
woman, slē'ni *or* tlē'ni.
,, old, clālakwa(sE slē'ni *or* tlē'ni).
,, married, swāwE kus.

yellow, lE'lits.
yes, ā'a.
yesterday, tsila'katlitl.
youth, swē'wolus.

Archæological.

The archæology of the district, comprising the territories of the Halkōmē'lEm tribes of the mainland, has already been treated of in part elsewhere.[1] I shall therefore at this time content myself with a general summary of my investigations over the whole field. These have been carried out at various points at different times during the past ten years, partly at my own desire and partly at the request of the late Dr. G. M. Dawson, Director of the Dom. Geol. Survey, on behalf of the National Museum at Ottawa.

The archæological remains found in the Lower Fraser district fall very naturally under two heads—middens and burial mounds or tumuli. In treating of the former it will be convenient to divide them into two classes, the ancient and the more recent. The earlier ones are characterised throughout by their abundant external and internal signs of comparative antiquity, and by certain somatological evidence of the presence of a race here during the time of their formation differing radically in important physical traits from the present Salish tribes.

As the older middens do not differ materially from each other wherever found except in regard to their extent and mass, I shall confine my description in the main to one very large one on the right bank of the north arm of the Fraser, a few miles up from its present mouth. The evidence of antiquity is, in the case of this midden, clear and unmistakable. First, in the growth upon it of an old forest, the trees of which are, in numerous instances, from 4 to 8 feet in diameter, and their annular rings indicate an age of 500 years and upwards. The roots of these trees are embedded in the midden mass itself and have demonstrably grown there since the site was abandoned and given over to nature by its original occupiers. Secondly, in the extensiveness and volume of the midden material which stretches along an ancient bank of the river—which is here some 200 or 300 yards back from the present bank—for upwards of 1,400 feet, covering, to an average depth of about 5 feet and to a maximum depth of over 15 feet, an area exceeding 4½ acres in extent. It is composed of the decaying remains of marine shells, mostly of the clam and mussel kind, intermingled with enormous quantities of ashes, calcined and fractured stones, and other refuse matter, and throughout its entire mass offers unmistakable testimony of extreme age. It will not be necessary to recapitulate here the evidence which I have set forth in detail in support of this in the publications referred to before. In my own mind there can be no doubt at all that this and the other middens of its class were formed many centuries ago by the predecessors of the present Salish bands. In the lower horizons of this midden several skulls have been taken out of a type wholly different from any to be found among the present tribes of this region. They are markedly dolichocephalic, whereas the general type of skull of the present Indian is markedly brachycephalic. The measurement of two of these formerly in my own possession shows the cephalic index to be in both instances under 74. According to the tables of physical characteristics of the Indians of the North-West,[1] the minimum cephalic index of the Delta tribes is 80, while the maximum reaches to 93·1, and in a total series of fifty-five cases the average index was 87. It is plain, then, that the difference here is extremely wide. Another striking feature of these crania, which even more strongly differentiates them from the Lower Fraser type, is the remarkable narrowness of the forehead and the lofty sweep of the cranial vault, both features contrasting strikingly with the receding foreheads and broad flattened heads of the historic Delta tribes. I may also add that Dr. F. Boas, to whom I gave one of these skulls, concurs with me in regarding these crania as radically different in type from any now known in this region.

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[1] See the writer's notes on 'Later Prehistoric Man in British Columbia,' *Trans. Roy. Soc. Can.*, vol. i., sec. ii., 1895–96; and 'The Prehistoric Races of British Columbia,' Christmas Number of the *Mining Record*, Victoria, B.C., 1899.

Of the relics recovered from this midden most are simple in make and design, and such as are, with few exceptions, found among primitive peoples elsewhere. I have figured some typical specimens of these in my 'Notes on Later Prehistoric Man in British Columbia,' and in my 'Prehistoric Races of British Columbia.' No pottery of any kind has been found in any of the middens of either class; indeed, the ceramic art appears to have been wholly unknown to the aborigines of British Columbia, both ancient and modern. Of stone bowls or basins a great number and variety have been recovered. Some of these are fashioned after the likeness of animals and fish, the bear, frog, and salmon being the favourite patterns. Occasionally the bowl represented a human head with the face on one side of it. Large numbers of barbed and grooved bone spear and arrow points, as well as stone adzes, axes, fish and skinning knifes, chisels, scrapers, &c., are found. Some of these are of the rough 'palæolithic' type, others are finely wrought and polished 'neoliths.' The two are commonly found side by side. The material out of which these stone tools and weapons were made was of various kinds. The fish-knives were invariably of thin slate. The adzes, axes, and chisels were commonly formed from dull green or grey and mottled jade, though specimens wrought from smoky quartz have been recovered. A dark grey or black basaltic rock was also extensively used, principally for spear and arrow heads. The latter were also made from slate, and when so formed were invariably ground into the required shape. These were generally stemmed but never barbed. A striking feature of some of these slate arrow-points is that the edges are bevelled from different sides, as if designed to give a rotary motion to the projectile; but these are not common forms. I have seen but one of this type. A few specimens of obsidian have also been found. In form and variety almost every known type of arrow-head will be found represented here.

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[1] See Tenth Report on the Physical Characteristics of North-West Tribes of Canada, by Dr. F. Boas (Brit. Assoc. Report, 1895, p. 17).

Stone swords of several patterns were also used by these midden makers. Some of them resemble in general outline the short double-edged sword of the Roman legionaries; others resemble, in cross-section, in a general way a ship's belaying pin. The ends of the handles of all these swords were pierced with a counter-sunk hole, the boring being done from both sides and meeting about the middle. Through these holes were doubtless threaded the leathern thongs which bound the weapons to their owners' wrists. Bone needles of various forms and sizes, with the eye-hole sometimes in the centre, sometimes at one end, are quite common. A few specimens of the pestle-hammer have also been recovered from this midden, though I met with no specimen of the kind in my own investigations. These do not differ in any radical feature from the types found in the later middens of this region. Indeed, I am free to confess that although I hold the more ancient of the middens to have been formed by an antecedent non-Salishan race, the specimens recovered from them do not differ in any remarkable degree from those found in later formations or from the utensils and weapons formerly employed by the present Salish tribes when we first came into contact with them. But while this is true it must be borne in mind that we have some types of utensil, notably the several varieties of the pestle-hammer, which are peculiar to, and probably originated in, this region; and these may very well have been borrowed by the Salish from their dolichocephalic predecessors. If this view is not well founded then it would appear that we have in these ancient middens very clear evidence of the antiquity of the Halkōmē'lᴇᴍ tribes in their present habitat. But this I seriously doubt. The evidence gathered from a comparison of their tribal customs, beliefs, and speech, especially of the latter, makes it impossible to believe that they could have occupied their present quarters as separate and distinct tribes since the days of the early middens. For by the most conservative calculations the lower strata of these old middens, such as that I am describing, could not have been formed less than a thousand years ago; and from what we know of the rate of dialectic change, phonetic decay, and the evolution of new forms in human speech, and particularly in barbarous and unlettered tongues, less than one half of that period would have brought about such dialectical differences in the language of the outlying and distant tribes as would long ere this have made them mutually unintelligible. Yet such is not the case. The Halkōmē'lᴇᴍ tribes from Yale to the Fraser's mouths and down the Sound all speak what is practically a common dialect. This fact makes it impossible to believe that these tribes have occupied the delta for any very considerable period, and yet everywhere throughout the whole area these ancient middens, many of them acres in extent, abound.

Adjoining the Halkōmē'lᴇᴍ tribes of the Delta and Sound are other Salish tribes, such as the Sk·qō'mic, Siciatl, Stlatlumʜ, and N'tlaka'pamuQ, whose dialects in some instances differ among themselves as much as Spanish does from Italian or Portuguese. On Vancouver Island it is the same. There we find a branch of the Halkōmē'lᴇᴍ division whose speech is quite intelligible to their kindred of the mainland, while that of the contiguous tribes is strange and practically unintelligible to them. The tribes of the Lower Fraser border upon the Sk·qō'mic settlements, whilst over a hundred miles divide them from the upper bands of the Fraser; yet the speech of both upper and lower is practically alike, while that of the neighbouring Sk·qō'mic (a non-Halkōmē'lᴇm division) is so different as to be unintelligible. There can be but one explanation of this. The Halkōmē'lᴇm were formerly less scattered, and lived in closer contact with each other; in other words, occupied a more compact territory than their present one. It is a significant fact, too, I think, that in no case do we find their genealogical records extending beyond nine or ten generations at most. In regard to this I cannot forbear thinking that if the names of nine or ten lineal chiefs can be handed down orally from father to son, then the names of twice or thrice that number might have come down in the same way. It is so among the different Polynesian tribes. Their genealogical list extends back for twenty or thirty generations, in some instances even further, and the record with them as with the Halkōmē'lᴇm is wholly oral. This uniform limitation of their genealogical records to nine or ten generations among the Halkōmē'lᴇᴍ tribes I regard as significant: to my mind it indicates that their separation into distinct tribes, with chiefs of their own, and their settlement in their present territories took place no longer than nine or ten generations ago, and this is about the period which on analogy would be required to bring about such differences as we now find in the speech of the upper and lower tribes. It seems clear, then, that the Halkōmē'lᴇm tribes could not have formed these old refuse heaps. Whether these tribes displaced other Salish tribes who preceded them in these parts or whether they succeeded the ancient midden makers themselves, and subdued, absorbed, or exterminated them, it is impossible at this stage of our investigations to say. There is, however, one feature in the beliefs of the Kwa'ntlᴇn tribe which seems to favour the latter view. For according to a Kwa'ntlᴇn tradition, at the time of the creation of their ancestor the Kwīkwitlᴇm tribe was also brought into being to be the slaves and servants of the Kwa'ntlᴇn. That this tribe was held in servitude by the Kwa'ntlᴇn, and despised by them and other tribes, is historically certain. It is told also in the Kwa'ntlᴇn traditions that one of their chiefs looking across one day from the slope on which the city of New Westminster now stands to the level marshy flats on the other side of the river, which the village of Brownville now occupies, conceived the idea of turning them into a fishing camp, and forthwith compelled the Kwīkwitlᴇm to convey there in their canoes immense quantities of rock and earth until the flats were raised sufficiently high to be suitable for a camping ground.

Whether we see in the Kwīkwitlᴇm a broken and subdued remnant of the predecessors of the Halkōmē'lᴇm tribes I do not take upon myself to say, though I regard it as by no means improbable. But I find no hesitation at all in saying that these older middens were not the ancient camping grounds of the tribes now settled in their vicinity. Indeed I seriously question whether the Salish stock was broken up into groups and tribes, as we now find it; or that the Salish language of British Columbia had been differentiated into its present numerous dialects at the time of the formation of the old middens of British Columbia. Nay, I will go further, for the linguistic evidence I have gathered from my studies of the Salish and Kwakiutl-Nootkan tongues warrants the assumption, and say that probably less than a millennium ago the ancestors of both these stocks dwelt together as one people and spoke a common language. Where the original home of this undivided people was, or what territory they occupied before their advent here, is a question we shall have to consider later. But wherever it may have been [1] it is abundantly clear that it was not the shores and bays of British Columbia or indeed those of the adjoining States. For almost every division of these two stocks have distinct names for the six different species of salmon and the other varieties of fish found in these waters; which could not conceivably have been the case had they lived together here before their separation, as fish, and above all salmon, is their staple food, and has been time out of mind. And not only have they different names for the fish themselves, but also widely differing myths to account for their origin or rather presence in these waters.

The later or more recently formed middens are easily distinguished from the older kind. First by their general condition, and secondly because in most instances they are known to have been old camp sites of the present tribes. With very few exceptions we find the shell remains in the later heaps in a good state of preservation and freer from ashes and other earthy matter. So much is this the case that some of the shrewder settlers in early days converted some of these shell heaps into lime, for which commodity they found a ready sale. Of the relics recovered from them the majority are of stone. In the old heaps the reverse is the case, bone specimens preponderating. The later middens, too, are comparatively small and shallow, and, as far as my own investigations go, not nearly so rich in relics as the older and more extensive heaps. Taking both classes of middens together, the number and ubiquity of them are remarkable. The shores of the estuary and of Puget Sound, as well as the coast and islands generally, are literally covered with them. In the neighbourhood of Boundary Bay they stretch almost continually for miles along the sound. Between Ladner's at the mouth of the Fraser and Point Roberts in Washington State I found them in scores, sometimes situated several miles back from the water in the midst of thick bush and timber. These latter were generally specimens of the older kind; and like those on the Lower Fraser were composed before the forest grew there, and when the Delta was less extensive than at present, and the salt water reached farther inland.

The relative richness of these delta middens in relics is another remarkable feature of them. One may dig and search for days in some heaps and find scarcely anything, while others abound, or did formerly, in bone and stone specimens of all kinds. There is one at the river-side village of Hammond, on the Fraser, which has yielded an almost incredible number of the most interesting relics. It extends along the bank of the river for a considerable distance, and is now utilised as fruit and vegetable gardens, &c., for which purpose the midden matter is admirably adapted, being rich in the elements of plant life. The settlers who first cultivated this ridge collected hundreds of different specimens. These, unfortunately, for the most part were cast aside, or became broken or lost, or else were given to friends or chance visitors, and thus got scattered beyond recovery. Not a few found their way to eastern collectors and museums. Mr. Harlan Smith, of the New York Museum of National History, spent some weeks here with a staff of diggers two or three summers ago, and, I understand, secured many interesting specimens which are now in the museum at New York. I also paid a short visit here last summer on behalf of the Museum of the Dominion Survey at Ottawa and secured a few specimens of adzes, axes, chisels, fractured slate knives, pestle-hammers, spear and arrow heads, and the like. The limited means at my disposal necessarily restricted my investigations, much and deep digging being now required to secure anything of value or interest. The territory in the neighbourhood of this midden was formerly regarded as the summer camp of the Kē'tsi tribe, whose headquarters were at the head of Pitt Lake. Whether the ancestors of the Kē'tsi once dwelt here and formed this extensive midden is not at all clear. It possesses many features in common with the older middens, and was doubtless formed when the salt waters of the gulf came many miles higher up the estuary than they do now, and when the clam and mussel beds were not so far off as at present. Although the Kē'tsi are said to have claimed this camp as theirs, the condition and extent of the main mass of the midden demonstrably proves it to be of comparatively ancient formation. For my own part, if the Kē'tsi are to be regarded as a genuine branch of the Halkōme'lᴇm, of which there is some doubt, I do not see, for the reasons already given, how their ancestors could have formed this old and extensive midden.

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[1] See the writer's paper on the 'Oceanic Origin of the Kwakiutl-Nootka and Salish Stocks of British Columbia,' published in the *Trans. Roy. Soc. Can.*, vol. iv., sect. ii., 1898. The views therein set forth have met with the general concurrence of Tregear and other Polynesian scholars, and have been further strongly confirmed by my later linguistic studies of Columbian and Oceanic stocks.

I now pass on to a summary consideration of the burial mounds or tumuli of this district. Certain sections of the province abound in these, notably the delta of the Fraser, the shores of Puget Sound, and the southern half of Vancouver Island. In the latter place they are found stretching from Nootka Sound on the west to Comox on the east. Wherever these structures are found, though they sometimes differ considerably in detail, they share, in the main, certain general characteristics. I have already described in detail one of the most interesting groups of these situated at Hatzic on the Fraser, and given illustrations of their internal and external structure, and figured the few relics recovered from them in my earlier publications on these subjects referred to before, and so shall here only treat very generally of them as far as they are found in the Halkōmē'lᴇm territory. In the groups on the Fraser, though they all consist of heaps of clay and sand and boulders, they differ one from another considerably in detail. Some were simple mounds of clay which had been heaped up over the corpse to a height of several feet. The diameters of these varied from 3 to 20 or 25 feet. These smaller ones were doubtless graves of children. The bones in all these clay mounds that I examined were always wholly decomposed, and their remains so closely integrated with the soil that the fact that a body once lay there could only be discovered after careful search. I may here state that in all these Fraser mounds, as well as in all others I have opened elsewhere, only one body was interred. About this there is no doubt, and this fact of separate individual interment is certainly one of the most striking features of these tombs. Another peculiarity is that few or no relics are recovered from them. A few copper specimens were taken from one or two of the most elaborate of the Hatzic group, but not a single specimen of stone or bone of any kind; and it is the same of others elsewhere. If we take these groups in the order of their elaborateness the next in the series is a class of mounds formed in part like the clay ones, but differing from them in having a pile of boulders heaped up over and around the spot where the body lay. These boulders were afterward covered with the neighbouring soil, the pile when finished being from 4 to 8 or 10 feet high, according to the depth at which the corpse was placed. This was evidently at times laid upon the undisturbed earth; at others a basin-shaped hole was first excavated in the soil, and the body placed at the bottom of this. Another significant feature of these tumuli is the presence of charcoal in some of them. In several I found a distinct stratum, in places 1 inch thick, extending over the whole area of the structure some feet above where the body lay. This charcoal was evidently the remains of a sepulchral fire. In this connection I may here state that, as far as my investigations go, they show that the mound builders of the Halkōmē'lᴇm district did not, at times at least, practise quite the same mortuary customs as did those of Vancouver Island. For while it is clear that both made use of the sepulchral fire, those of the island seem to have frequently cremated the corpse and afterwards deposited the ashes and unburnt bones in a kind of pit or rough cist at the bottom of the mound. The evidence, however, on this head is not always as clear as one would desire. Nevertheless, there is no doubt that cremation was practised by the island mound builders, while this custom seems to have been unknown on the mainland. What was consumed in these sepulchral fires it is impossible now to say, though, judging from more recent practices of the kind, it may well have been merely food for the shade of the departed or his clothes or other personal belongings Mortuary fires for this purpose are not unusual among primitive races, and were, we know, commonly lighted among the tribes of this region until quite recently.

Next in the series we find a class of mounds which may be said to be typical of the greater number of these structures wherever found. These differ from the last described in having a rectangular periphery of stones. Elsewhere on the Fraser, on the mountain slopes overlooking Sumas Lake, at Point Roberts on the Sound and almost everywhere on Vancouver Island, we find mounds of this class. These inclosures vary in diameter from about 10 to 50 feet. Sometimes they are proximately true squares, at others they are decidedly oblong in shape. The greater portion of the space contained by these boundaries is covered with the central pile of boulders or rocks, and over all is thrown the soil or clay of the neighbourhood, which is not infrequently interstratified with different coloured sands. Sometimes we find this type considerably elaborated, and instead of one boundary of stones we have three, one inclosing the other, with an interval of a few feet between them, with the outermost doubled and capped by an additional row. The stones of which these tombs are constructed vary in character with the locality in which they are found. All those at Hatzic were formed of water-worn boulders, and had to be conveyed to the spot from the mountain streams, a mile or so away from the site. They weighed from 25 pounds to 200 pounds each, and the total weight of them in one of the more elaborate mounds could not have been less than 25 tons or 30 tons. It will be seen that the building of some of these tombs was no light task. Those found on the mountain slopes overlooking Sumas Lake are in every case with which I am familiar built of jagged blocks of stone, of varying weight and size, taken from the mountain side. In other respects they do not differ in any essential particular from the typical ones at Hatzic. But some of those on Vancouver Island might be more aptly termed cairns than tumuli, as they are constructed without clay or sand or soil of any kind, the pieces of rock or boulders being piled up in conical form over the body, much as we find them in the Scotch cairns.

I have already alluded to the different kinds of sand found in some of these structures. I regard this as a remarkable feature. What its presence signified, I am unable to say; but that it had some special signification there can be no doubt. It is found in all the larger of the Hatzic mounds, sometimes in large quantities, and also in those near Sumas Lake and at Point Roberts; and it is also quite frequently seen in those on Vancouver Island. This sand is sometimes spread over the structure in distinct layers or strata of varying thickness. Sometimes in the same mound we have layers of dark reddish or brown sand alternating with layers of clay and dark-grey sand. In no instance is this sand the natural soil of the place where the mounds are erected, but has been laboriously brought from some other spot. I may here state that the Indians who live in the vicinity of these tumuli know nothing about them or their builders. Burial by inhumation was never practised in the Delta district by the present tribes as far as they themselves know, or as far as their traditions reveal. Burial in or under trees; in roughly constructed wooden tombs, erected on poles; in large family box-like receptacles; in blankets or in separate coffins or boxes, which were placed under sheds in the burial grounds, or suspended from the branches of trees, was the prevailing custom among these tribes when we first came into contact with them, and as far back as they have any record of. I have already pointed out my reasons for thinking they could not have occupied their present territory beyond a few centuries at most, and the presence among them of these old tombs, disclosing this strange mode of sepulture, of which they know nothing, seems to confirm this view. The conservation and perpetuation of well-established customs are a very strong trait in the character of primitive man all over the world, and though changes and modifications may and do, by lapse of time or alteration of circumstances, take place, yet we rarely meet with cases of such radical change as that which must have taken place here if the present tribes are the descendants of the mound builders. Unfortunately we have thus far been able to secure so little somatological material from these tombs that it is impossible to institute comparisons between the morphological characters of the mound builders and those of the modern tribes, and so determine the question, if possible, by this means. In only one instance did I succeed in recovering a few bones and a portion of a skull, the examination of which has only made the question more perplexing. This skull had been subjected to considerable pressure in the ground, and had in consequence suffered very much from deformation *post-mortem*. To make the matter worse, it had also been deformed in the lifetime of the individual to whom it belonged; and although Dr. Boas inclines to the belief that such of the face as is left presents features in common with the heads of the present Indians, the evidence in support of this is of so scanty and inconclusive a nature that it can scarcely be taken into account. This fragmentary skull, then, does not afford us much help. There is, however, one point of interest about it. It appears to be the skull of a woman. If it be so, then the honours paid to deceased wives or women among the mound builders were very much greater than those paid to deceased wives or women among the Halkōmē'lᴇm tribes, past or present, as far as we can learn. That these mound builders are an old race, and some of their tombs of great age, we may gather from the fact that out of the crown of the one from which the deformed skull was taken—and which was probably the cause of its partial preservation—there stood the decaying stump of a large cedar-tree, which could not have been less than several centuries old. From this it is clear that this mode of sepulture dates back to a comparatively remote period, too remote, I think, to have been known or practised by the ancestors of the Halkōmē'lᴇm tribes. Deep-rooted customs such as these widely scattered monuments of a bygone age reveal do not change easily, or give place readily to others so radically different.

In concluding this paper I may be permitted to briefly sum up the results of my investigations of the archæological remains found within the Halkōme'lᴇm borders. First, we gather from the evidence of the older middens that the Lower Fraser was in possession of a primitive people at a comparatively remote date, probably not less than 2,000 years ago; that the cephalic index and the general contours of the heads of at least some of these differed radically from those of any tribe that now exists or has been known to exist here; and that these or some other equally unknown people practised important mortuary rights and customs altogether unlike those practised by the present tribes, or known to have been practised in the past by them. From these results and from my linguistic studies, which show that the speech of the Halkōme'lᴇm tribes, distantly separated as some of them are, is practically homogeneous, which could certainly not be the case if these scattered tribes had occupied the Lower Fraser district from the period of the earlier middens and burial mounds, we may fairly conclude that the present Salish tribes are not the original occupiers of this portion of the province; that they are, in fact, comparative late-comers. Who, or of what race, were the ancient midden and mound builders, whether they were related to the De'ne' of the interior who once undoubtedly occupied a greater portion of Southern British Columbia than they do now, or to some other unknown race which has been exterminated or absorbed, future investigations may one day reveal to us.

Anthropological Photographs.—Interim Report of the Committee, consisting of Mr. C. H. Read (*Chairman*), Mr. J. L. Myres (*Secretary*), Dr. J. G. Garson, Mr. H. Ling Roth, Mr. H. Balfour, Mr. E. S. Hartland, *and* Professor Flinders Petrie, *appointed for the Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest.*

The Committee report that steady progress has been made with the registration of anthropological photographs; but that it has seemed desirable to postpone once more the publication of a classified list until the numerous photographs recently submitted can be thoroughly catalogued and cross-referenced.

The thanks of the Committee are especially due to the Librarian of the India Office, and to the Royal Geographical Society, for leave to register the large collections of photographs under their care: as well as to the numerous owners of negatives who have communicated with the Committee.

The Committee ask to be reappointed, with the balance in hand from the original grant.

The Roman Fort at Gellygaer.—Report of the Committee, consisting of Professor J. RHYS (*Chairman*), Mr. J. L. MYRES (*Secretary*), Mr. A. J. EVANS, *and* Mr. E. W. BRABROOK, *appointed to co-operate with the Cardiff Naturalists' Society in its Excavations on the Site of a Roman Fort at Gellygaer.*

THE Committee has received from Mr. John Ward, F.S.A., of the Cardiff Naturalists' Society, the following report of the exploration :—

The village of Gellygaer lies between the Rhymney and the Bargoed Taff valleys, near the north-east border of Glamorgan, and at a distance of thirteen and a half miles N.N.W. of Cardiff. It occupies a high position (780 feet above the sea), and commands an extensive sweep of characteristic Coal-measure country, for this village is in the heart of the eastern part of the South Wales coal-field.

The site of the fort is in a field to the north-west of the church, which has, time beyond memory, borne the name of Gaer Fawr (Great Camp). Here a number of low mounds bore witness to the significance of the name, for to an experienced eye they marked the outline and chief buildings of a typical Roman fort. The position is not naturally strong, yet it is well chosen. It occupies a commanding position on the brow of Nant Cylla, but is overlooked by rising ground on the north-west.

The exploration, for which permission was given by the owner of the property, Mr. Capel Hanbury Leigh, J.P., began in October 1899, and was continued during the warmer months each year until the end of autumn 1901. During its progress the whole of the site was sufficiently excavated to admit of a survey being made of all the buildings, some of the more important being wholly uncovered. It shares with Housesteads on the Roman Wall in Northumberland the distinction of being the most completely explored Roman fort in this country.

The survey of the remains, made by Mr. J. W. Rodger, of Cardiff, presents a typical Roman fort, singularly complete, and characterised by great simplicity. The outer line of defence, it will be observed, is the usual ditch, which, in the case of Gellygaer, was crossed at the gates by bridges ; the inner, an earthen rampart, faced on both sides by retaining walls. This rampart is pierced by four gates, one about the middle of each side. Besides the chambers which flank these gates, there are twelve others, probably the basements of towers, at approximately equal distances along the rampart, one being at each corner. Connecting the lateral gates is the wide transverse street, the *Via Principalis*, and midway on its south-west side is the forum-like structure invariably found in these forts, and usually denominated the *Prætorium*. This structure, as usual, breaks the continuity of the longitudinal street. The rest of the site is occupied by buildings of several types, corresponding in the main with those of other forts.

The length reckoned from the external face of the rampart is 404 feet and breadth 385 feet, so that this fort is one of the smallest of the British excavated series, and it is a shorter oblong than usual. Another peculiarity is the backward position of the *Via Principalis*.

The various buildings, including the rampart revêtements, were found to rarely remain to a greater height than 3 feet above the Roman level. They were constructed of the local Pennant gritstone, a hard, thinly bedded rock, which is still the chief building material of the district. The masonry may be described as regularly coursed rubble-work, but it varied considerably in quality. The gates, for instance, were neatly constructed of well-selected stones, many of which were more or less dressed. Some of the walls of the buildings of the interior, on the other hand—probably sleeper-walls to support superstructures of timber—were built of rough stones as quarried, with an admixture of weathered field stones. The voussoirs of the gate arches were of calcareous tufa.

Mortar had been used in all these walls, but it was found, as a rule, to have decomposed into sandy loam of the same colour as the surrounding soil. This proneness to decomposition was apparently due to the use of 'white' lime, *i.e.*, lime derived from Carboniferous limestone, and the inability of getting a suitable sand in the district. This limestone, together with the calcareous tufa just referred to, is found in the vicinity of Castle Morlais, ten miles to the north-west.

The foundations of all the outside and of most of the divisional walls were deep and well laid, consisting of rough quarried and field stones, roughly coursed in the case of the more important walls, and packed on end in the case of the less important.

The roofs of several of the more important buildings had been covered with red tiles of the usual Roman type; but from the absence of roofing tiles of any sort on the sites of others, particularly the 'long' buildings, it may be inferred that these buildings had been thatched or covered with wooden shingles or planks.

The ditch was found to be of a shallow V-shape in section, approximately 19 feet in width from lip to lip and 7 feet in depth; and owing to the tenacious character of the natural soil, the sides were singularly well preserved. The excavation in front of the south-west gate showed that each side of the ditch had been cut back so as to leave a step about 2 feet from the bottom, obviously to serve as a platform for the supports of a bridge; and from the absence of masonry it may be concluded that the bridge was of wood.

As already stated, the rampart was of earth (evidently derived from the ditch) and confined between two walls. The outer of these walls varied from 3 feet to 4 feet 3 inches in thickness, and the inner was considerably thinner. Both walls had been built *against* the earth-bank. The total width of the rampart varied from 19 feet 4 inches to a trifle over 20 feet.

All the gates, so far as could be judged from their remains, were of similar design and size. They were double—that is, each contained two passages, 11 feet long and wide, separated by an intervening *spina*. Front and back these passages were narrowed to portals 9 feet 6 inches wide by projecting jambs or pilasters, which doubtless had carried arches, as the fragments of voussoirs of calcareous tufa were plentifully found on the sites. On either side of the pair of passages was an oblong guard-chamber about 11 feet by 9 feet 6 inches (internal measurements), entered by a narrow doorway in the back.

The whole structure (passages and guard-chambers) was within the width of the rampart, and the front pair of portals was set back nearly 6 feet behind the front line of the rampart. These portals had been provided with two-leaved doors, which turned on pivots. These in closing stopped against a rim or sill of stone which crossed the threshold, and in opening fell back into the recesses made by the projection of the pilasters. In one of the passages of the south-west gate the raised sill, pivot-holes, and bolt-holes were found intact, the former consisting of two flag-stones end to end, and set on edge in the ground, the upper edge being worn by traffic.

From the presence of red roofing-tiles on the site of the north-east gate it is probable that the gates were roofed with these tiles.

The building (VII) designated by some the *Prætorium*, and by others the *Forum*, was the most central and probably the most important feature of the interior of the fort. It was oblong in plan, 80 by 68 feet, and was of simple type, consisting of (*a*) an interior courtyard entered from the *Via Principalis*, and surrounded on three sides by a narrow-roofed ambulatory; and (*b*) a posterior portion consisting of a space which may be regarded as the enlarged ambulatory of the fourth or far side of the courtyard with a range of five rooms opening into it. The middle room was distinguished from the rest by its external projection, in this respect resembling the corresponding room in some of the German *prætoria*.

On the north-west side of the *Prætorium* was a house-like structure (VI), consisting of a series of rooms, which opened into a corridor surrounding a small central court, entered from the *Via Principalis*.

On the opposite side was an enclosed yard, which also had its chief entrance from the above street. This yard was not fully explored, but the trenches sufficiently showed that it was used for various purposes.

Between these and the lateral gates were two remarkable buttressed buildings (V and VIII), each about 83 by 35 feet. Remains of similar buildings have been found in most Roman forts, but nowhere else have they supplied so many hints as to their original construction and arrangement. Each of the Gellygaer examples consisted of a middle portion having a raised floor of wood or other perishable material, supported upon a number of parallel sleeper-walls. In these walls, and between the buttresses of the external walls, were openings, evidently to allow of the free circulation of air between this raised floor and the ground. The roof above had been tiled in the usual way. At each end were the remains of a sort of portico, containing an entrance into the middle portion, reached by several steps. Of the various conjectures as to the use of these buildings the most feasible is that they were storehouses.

The four buildings described above, formed a range along the south-west side of the great cross street, the rest of the interior being occupied by a number of narrow transverse buildings, which apparently had been thatched, for no roofing tiles of any sort were found on their sites.

Six of these (I, II, XII, XIII, XIV, XV) were alike, L-shaped, and their average length was 145 feet and width 36 feet. For about two-thirds of their length (corresponding to the upright limb of the L), however, the actual wall on one side was recessed or set back about 6 feet, the full width being maintained along this portion by a row of nine posts, which evidently supported the overhanging roof, forming a veranda.

Buildings of a similar shape, but with stone pillars instead of wooden posts, have been found at Chesters (*Cilurnum*), in Northumberland. As these were divided into a number of narrow apartments opening on to the veranda, it is probable that the Gellygaer examples were similarly divided, only by wooden instead of stone partitions. These buildings were probably used for barracks.

The other 'long' buildings differed from one another in shape and size, and it is likely enough that they were used for different purposes.

A complete Memoir of the exploration, with plans, &c., drawn up by Mr. John Ward, F.S.A., for the Cardiff Naturalists' Society, has now been published. Application for copies should be made to the hon. secretary of the Society, Dr. William Sheen, Cardiff.

Silchester Excavation.—Report of the Committee, consisting of Mr. ARTHUR J. EVANS (*Chairman*), Mr. J. L. MYRES (*Secretary*), *and* Mr. E. W. BRABROOK, *appointed to co-operate with the Silchester Excavation Fund Committee in their Excavations.*

THE Committee have to report that the excavations at Silchester in 1901 were begun on May 10, and continued without break until November 13.

The work was confined to the northern half of the town, on a strip of ground lying to the east of *insulæ* XXI and XXII (excavated in 1899), and extending northwards from the modern road traversing the site to the town wall. The area examined was nearly 6 acres.

The ground in question was found to contain, in its southern half, a square *insula* (XXVII) of large size, while the triangular piece to the north proved to be an extension eastwards of *insula* XXII, of which the larger portion was excavated in 1899. The extension contained only two more buildings; one towards the north; the other towards the south, perhaps a small house with an eastern apse.

The western half of *insula* XXVII contained the foundations of three houses. Two of these are especially interesting on account of the additions that have been made to their plans. The northernmost house, which by these additions was more than doubled in area, was originally a complete example of the courtyard type, with mosaic floors in most of the rooms, and a number of interesting features. Two of the mosaic pavements were sufficiently well preserved to justify their removal. The house was evidently a half-timbered building, and in the added portion some remarkable evidence was found of the method of construction and the ornamental character of the half-timbered work.

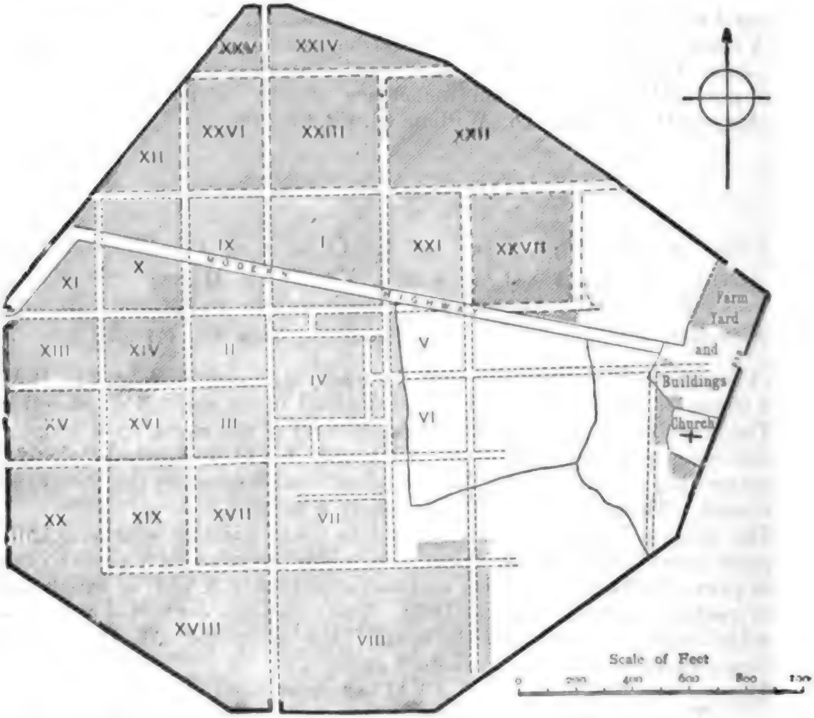
The second house was also of the courtyard type, but apparently of less importance than its neighbour, and perhaps of later date. The additions to it included a number of winter rooms warmed by an elaborate series of hypocausts, and a building of doubtful use exhibiting some unusual features of construction.

The third house was of the corridor type, but its more interesting portion had been to a large extent destroyed.

The extensions to the houses noted above stretch so far across the *insula* as to leave little room for any other buildings, and those that were uncovered were not of an important character.

The number of pits and wells met with in 1901 was small in comparison with the many found in previous years, but they yielded a fair quantity of pottery and other antiquities, including a fine pair of iron wheel tyres, and a remarkable lead or pewter bucket.

The annexed plan of the Roman town shows the portions excavated down to May 1902.


XXV
XXIV
XXVI
XXIII
XXII
XII
IX
I
XXI
XXVII
X
XI
MODERN HIGHWAY
Farm Yard
and
Buildings
Church
XIII
XIV
II
V
IV
VI
XV
XVI
III
XX
XIX
XVII
VII
XVIII
VIII
Scale of Feet
0
200
400
600
800
1000

The finds in bronze, bone, and glass, and the coins, were as numerous as usual, but do not call for any special remark.

A detailed account of all the discoveries was laid before the Society of Antiquaries on May 29, and will be published in 'Archæologia.'

A special exhibition of the antiquities, &c., found, was held, as in former years, at Burlington House, by kind permission of the Society of Antiquaries.

The statement of accounts for the year 1901 shows a total expenditure of 510*l*. 15*s*. 8*d*.

It is proposed during the current year to excavate the area near the east gate, adjoining the churchyard of the parish church of Silchester, to the west of the two square temples uncovered in 1890.

The Committee, therefore, ask to be reappointed, with a further grant.

The Age of Stone Circles.—Report of the Committee, consisting of Dr. J. G. GARSON (*Chairman*), Mr. H. BALFOUR (*Secretary*), Sir JOHN EVANS, Mr. C. H. READ, Professor R. MELDOLA, Mr. A. J. EVANS, Dr. R. MUNRO, Professor BOYD DAWKINS, *and* Mr. A. L. LEWIS, *appointed to conduct Explorations with the object of Ascertaining the Age of Stone Circles.* (*Drawn up by the Secretary.*)

THE Committee report that the excavations commenced last year at the Arbor Low Stone Circle in Derbyshire, were renewed towards the end of May of the present year, the necessary permission having again been very kindly granted by the Duke of Rutland, the First Commissioner of Works, and Mr. Warrilow, the ground tenant, and this opportunity is taken for thanking these gentlemen heartily for having thus enabled the work to be further prosecuted. As last year, so again this year Mr. A. Pitt-Rivers was good enough to lend the principal apparatus employed, for which sincere thanks are due to him. The actual organisation and carrying out of the excavations were again placed in the hands of Mr. H. St. G. Gray, of the Taunton Museum, and the Committee wish to testify to their high appreciation of the manner in which he conducted the work under somewhat trying circumstances. He has completed his elaborate survey plans with sections illustrating this year's diggings, and has, during last year and this year, taken between thirty and forty photographs showing views of the monument, the excavations, and principal finds. He is further constructing a relief model which will accurately represent the entire structure. Considerable time and attention was devoted to the relaying of the turf covering the parts disturbed during last year's excavations. This was satisfactorily performed, and as arrangements have been made with the tenant whereby cattle and horses will be kept out of the field until next spring, it is hoped that the turf will now settle properly and that all traces of disturbance will disappear in a short time.

The following detailed account of the work done this year has been submitted by Mr. Gray as a report to the Committee.

On the Excavations at Arbor Low, May–June 1902.

By H. ST. GEORGE GRAY.

Little need be said this year in a prefatory way as regards the position of Arbor Low and its general description, these points having been dealt with somewhat exhaustively in last year's report. The various dimensions of the circle and earthworks were also given, and the surveys, sectional diagrams, and photographs were fully described.

Excavations were renewed this year on May 27, and continued until June 9. For the greater part of the time eight men and a boy were employed as against a maximum of six men and a boy last year. A fairly large amount of time and labour had to be expended in relevelling and returfing last year's excavations, for it was found that cattle, combined with dry weather after the completion of the work last year, had played great havoc with the relaid sods; indeed, fresh turf had to be obtained and cut with proper tools for the purpose of returfing. The excavations of 1901 and of 1902 have now been left in as good a condition as possible, and arrangements have been made with the tenant-farmer to keep the field in which Arbor Low is situated free from cattle and horses until Lady Day 1903, so that the relaid turf may have ample time to recover itself. The weather during the explorations was most unpropitious, there being only two thoroughly fine days. Heavy rain fell during a large proportion of the time, which greatly impeded the men in the filling in of the new excavations and in the returfing operations. This year's photographs, in spite of the weather and of several having been taken in drizzling rain, are on the whole satisfactory.

I was unable to determine the magnetic declination of the compass, but Mr. Charles Lynam, F.S.A., kindly ascertained for me that it was 17° 53′ at Buxton in 1901.

An accurate model of Arbor Low is in course of construction and will probably be completed by about the end of this year. I regret that it has been impossible to finish it in time for exhibition at the Belfast Meeting of the British Association.

Excavations into the Fosse.—In August 1901, as already reported, three cuttings were made across the ditch, viz., Section 1, measuring $3^{\mathrm{m}}\cdot66$ wide, at the south, close up to the S.S.E. Causeway; Section 2, $3^{\mathrm{m}}\cdot05$ wide at the N.W., with an extension up to the limestone sides of the N.N.W. Causeway; and Section 3, also $3^{\mathrm{m}}\cdot05$ wide, midway between Section 1 and the N.N.W. Causeway, in all $14^{\mathrm{m}}\cdot34$ of fosse. This year three further cuttings were made, comprising $11^{\mathrm{m}}\cdot60$ of fosse. The re-excavation of each of these sections will be described in detail.

Section 5, $3^{\mathrm{m}}\cdot05$ wide, is situated on the west, between Sections 2 and 3 of last year. Like Section 3, it proved to be very shallow, the limestone rock being reached in the middle of the silting at a depth of 30 cm. from the surface, whilst on the inner side of the ditch the depth was only 24 cm.; the section was not therefore surveyed and plotted. The bottom was fairly level, especially when compared with the bottom of the fosse in all other parts except in Section 3. No relics were found in Section 5, except one doubtfully artificial chert flake. The photograph, taken from the N.W. vallum, of the general view of the barrow on the S.E. vallum and portion of the circle, shows in the foreground in the right-hand corner the position of this section in its returfed condition at the close of the excavations.

On the east by north, another cutting, Section 6, $3^{\mathrm{m}}\cdot05$ wide, was made across the fosse. Here again nothing of importance was discovered, but the section was surveyed and plotted. In this part, the surface of the turf of the silting at the lowest part was $2^{\mathrm{m}}\cdot13$ lower than the general level of the ground immediately adjacent to the central stones. The average depth of the section below the surface of the silting was $1^{\mathrm{m}}\cdot37$ and the maximum depth $1^{\mathrm{m}}\cdot77$ in the N.W. of the cutting. The blocks of limestone on the S.E. rise to a height of only 18 cm. below the surface of the silting. On the E. and N.E. the median block of limestone which ran across the section was divided from the limestone side of the ditch on the E. by a vein of fine clay, yellowish-brown on the top and white below, which occurred at an average depth of $1^{\mathrm{m}}\cdot22$ from the surface of the silting. The surface mould in the middle of the silting reached a depth of 61 cm. below which was the usual stiff clayey mould mixed thickly with small fragments of chert; at the bottom the proportion of clay to mould increased, and the silting became more stiff and moist; in fact at the bottom had to be cut out in solid lumps with a small spade, the chances of nding relics consequently being very remote. The same remarks apply the silting at the bottom of the fosse of Section 4, next to be described.

Section 4 made across the fosse, $3^{m}\cdot05$ in width, and its extension estward to expose the limestone sides and end of the ditch at the N.N.W. auseway, proved to be the most interesting and productive of all the itch cuttings. The first 'find' here was an almost circular greyish-white hert or flint end-scraper, with edge of the usual semicircular form. One f the side-edges exhibits some fine secondary chipping: this edge would erve admirably as a knife; the conchoidal fracture side is very smooth, nd displays an extremely bold bulb or cone of percussion, surrounding hich some radiating 'tearing' of the surface of the chert is well seen—he result of a single blow. The dorsal ridge running along this scraper is ell marked, and is the result of a blow delivered above the divisional line f two adjoining and deep facets of the core from which the scraper was truck: it was found at a depth of 43 cm. (28 on plan and section). At 9 (plan and section), at a depth of 91 cm., close to the limestone side of he ditch at the S.E. of the section, about two-thirds of an extremely thin nd finely chipped flint arrow-head, of a light brownish-grey colour, was ound: its greatest width is 21 mm., its greatest thickness 2·7 mm. The base f this delicate implement is of semicircular form, whilst the side-edges of he perfect arrow-head, from the points of greatest width to the tip, appear o have been quite straight; thus it represents the lozenge-shaped form as egards its upper half, and the leaf-shaped variety in the lower half. On he bottom of the fosse, at a depth of $1^{m}\cdot74$ (43 on plan and section), under tiff clayey mould, was found the most interesting relic that Arbor Low has yielded during these excavations, viz., a barbed and tanged chipped rrow-head, of greyish-white flint or chert,[1] of extremely symmetrical form nd 25 mm. (1 inch) long, a small portion only of the tip being deficient; greatest width 21·5 mm., greatest thickness 5 mm. It is finely chipped ll over its surface, including barbs and tang, which latter are bevelled on both faces from median ridges to edges. The end of the tang, which is very slightly longer than the barbs, is also bevelled. The section across the arrow-head is bi-convex, but it is considerably flatter on one face than on the other. The cutting edges are slightly convex, owing to the fact that the barbs have an inward curve. Doubtless a good deal of care was expended on its manufacture.

Not far from this beautiful arrow-head, at a depth of $1^{m}\cdot46$ (37 on plan and section), a small rough chert scraper, with semicircular edge, was found: one edge is bevelled to a sharp chipped cutting-edge, and might have served well as a knife; the facets bear excellent examples of conchoidal fracture. In clayey mould, close to, at a depth of $1^{m}\cdot40$ (39 on plan and section), the greater part of a small horn of red deer, with four tines, in an extremely friable condition, was found; indeed only a portion of one tine could be preserved. At 21 on plan, depth 30 cm., a doubtfully artificial chert borer and a probably natural scraper, were found. The relics being so few comparatively, I have been reluctant throughout the excavations, both in 1901 and 1902, to throw away anything that *might* be pronounced by greater experts on stone implements than myself to bear traces of human agency. The surface of chert does not seem to alter like flint does from exposure and age; consequently it is often difficult, if not impossible, to decide whether certain fractures are ancient or quite recent.

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[1] My glass is not of sufficient power to determine whether this arrow-head is of chert or flint. The same remark applies to some of the other implements.

In the extension cutting to the west a greyish-brown flint flake with secondary chipping was found at a depth of 36·5 cm. (40 on plan and section): the bevelled edge on one side near the top is finely worked; the bulb of percussion is very prominent, on which is a well-marked facet, known in scientific terminology as an *éraillure*.[1] At 41 (plan and section) a small chert or flint flake was found, depth 12 cm. This completes the stone implements found in this part of the fosse. Of animal remains a tooth of sheep was found at a depth of 91 cm., portion of a humerus of ox at a depth of 1^{m}·52, and several small fragments of animal bones at various depths, too minute and friable for identification. Not to omit anything, it should be recorded that a Queen Victoria halfpenny, 1867, was found here near the causeway at a depth of 9 cm. below the surface of the turf. This is not surprising, as a coin trodden into the turf edgeways will gradually work its way downward a few inches during wet weather.

Four or five photographs of this portion of the re-excavated fosse were taken, and three sections were levelled and plotted.

This was the deepest portion of the ditch excavated, the maximum depth from the surface being 2^{m}·04. The bottom presented a very uneven surface; in fact, no attempt whatever appears to have been made to obtain even a reasonably level track along the bottom of the fosse. The same remark applies to the bottoms of all the other sections, with the exceptions perhaps of the shallow cuttings at sections 3 and 5 on the west. I was particularly desired to make observations on this point. Mr. S. Jackson recently found a flooring of poles at the bottom of a Bronze Age ditch at Fairsnape Farm, Bleasdale, near Garstang.[2] The bottom of a ditch cut in the chalk of a Bronze Age tumulus dug in 1898 at Whatcombe, near Blandford, by the late and venerable Mr. J. C. Mansel-Pleydell, for over forty years President of the Dorset Field Club, was observed by Professor Boyd Dawkins to be 'smoothed and polished into a perfectly well-defined track by human feet circling round the burial-mound.' This 'may have been intended for a ceremonial procession at stated times in honour of the dead.'[3] Chalk of course lends itself admirably to being smoothed by the constant friction of the feet, or even by means of such primitive tools as were used in the Stone Age; whereas, in the case of the fosse of Arbor Low, the process of levelling or smoothing the mountain limestone with its veins of chert, calcite, and other hard substances, would have bristled with difficulties. Although General Pitt-Rivers never actually recorded the fact, I am able to testify that the bottoms of several ditches surrounding Stone Age and Bronze Age tumuli which he re-excavated in the chalk in Cranborne Chase were perfectly smooth. Take, for instance, the case of the great Wor Barrow on Handley Down, Dorset: the bottom of the ditch was quite even and polished, especially the S.W. and W. portions, where the fosse was 3^{m}·96 deep and measured 6^{m}·40 in width at the top.[4] If the record of these facts has no other use, it will at least tend to impress upon exploring archæologists that there is yet another field of inquiry obtainable in ditch-digging.

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[1] 'Worked Flints from the Cromer Forest Bed,' by W. J. Lewis Abbott, F.G.S., *Natural Science*, vol. x., pp. 92 and 93.

[2] See Professor Boyd Dawkins's paper on the subject, *Trans. Lanc. and Chesh. Antiq. Soc.*, vol. xviii.

[3] Same paper, *Trans. Lanc. and Chesh. Antiq. Soc.*, vol. xviii.

[4] *Excavations in Cranborne Chase*, vol. iv., Pl. 253, fig. 1, and Pl. 249.

But to return to the Fosse of Arbor Low. From the western edge of the original cutting, Section 4, to the end of the excavation, called 'Ditch Extension, Section 4' (which was extended to the westward in search of the solid limestone causeway), the rock sides shelved up very gradually, as seen in one of the plotted sections. From the S.E. corner of the cutting and within 46 cm. from the surface, a 'spur' of solid limestone extended in a N.W. direction, sloping gradually and meeting in the middle of the cutting the limestone shelving up towards the middle of the causeway, on which long irregular ledges could be clearly traced which might well have served as steps to facilitate the process of ingress and egress to and from the bottom of the fosse before it became filled or partly filled with silting.

In the N.W. side of this cutting through the fosse, miniature caverns occurred in the solid limestone sides of the ditch. Careful search was made here for any objects that might have been hidden at the time the ditch was open to the bottom; our efforts, however, were unrewarded.

Although the photographs of this part were mostly taken in the rain, they well show the form and irregularities of the sides and bottom of the re-excavated ditch. Considerable traces of fire were observed at the bottom near the point where the barbed arrow-head, 43, was discovered, and also in the corner of the cutting on the S.E.[1] The silting, as before stated, was of the same nature as in Section 6 on the east.

This completed the examination of the fosse, 26 metres having been excavated in all, of the total length of 165 metres. In other words, nearly one-sixth of the fosse of Arbor Low has been re-excavated, and flint implements only have been found from top to bottom of the silting. The *mean* depth of the whole fosse excavated is $1^{m}\cdot19$.

As regards the arrow-heads, it is worthy of notice that the barbed-and-tanged specimen, a form generally considered to be the most highly developed, was found 82 cm. lower down in the silting than the arrow-head of leaf-shaped form, but approximating closely to the lozenge-shaped, a form which has generally been regarded as an earlier form than the barbed variety. It has not, however, yet been clearly ascertained which form of arrow-head was first manufactured, and the matter is at present surrounded with the greatest difficulty, inasmuch as the triangular, the stemmed, and the leaf-shaped varieties are recorded as having been found together in the same locality and in the same deposits. One form is easily evolved from another, and although General Pitt-Rivers' method[2] of arranging arrow-heads, showing the theoretical transition from one form to another is excellent in museum arrangement, until something more definite is arrived at, yet, bearing in mind the records of the circumstances of the finding of flint arrow-heads during the last thirty-five years, it would be, as Sir John Evans has said long ago, 'unwarrantable to attempt any chronological arrangement founded upon mere form, as there is little doubt of the whole of these varieties having been in use in one and the same district at the same time, the forms being to some extent adapted to the flake of flint from which the arrow-heads were made, and to some extent to the purposes which the arrows were to serve.'[1]

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[1] Dr. Garson has suggested that the traces of fire at this point may possibly indicate that this portion of the ditch, which is deep and would therefore afford some shelter from wind and storm, was occupied by persons employed in guarding the circle; hence the greater number of implements in this section and in the corresponding section excavated last year on the other side of the causeway.—*H. B.*

[2] Colonel A. Lane Fox's second lecture on 'Primitive Warfare,' *Journ. R. V. Serv. Inst.*, 1868, vol. xii., No. LI.

The two Arbor Low specimens were probably not used many years apart, for the fosse would, throughout its lower portions, and indeed within 30 to 60 cm. of the present surface of the silting, fill up somewhat rapidly, particularly at the bottom, owing to the fact of the sides of the ditch being exposed to the erosive force of the atmosphere, the action of rain and frost, and the consequent disintegration of the sides. In this way it will be readily understood that the width of the Arbor Low fosse, and indeed of all such ditches, at the top has increased during the process of silting up and denudation of the sides, whilst the width of the ditch at the bottom would remain very much the same as at the time of original construction. Naturally the sides of some ditches would disintegrate much quicker than others, the havoc played by frost and rain would leave its mark much more quickly in the case of the chalk than in that of the limestone, and thus the talus formed at the bottom of the ditch would be deposited much more rapidly in the former than in the latter case. The talus, as viewed by a spectator looking down into the ditch, would have a very pronounced concave surface, so that when the sides of the ditch become covered up nearly to the top, the depth of the talus in the *middle* of the ditch would not necessarily be more than, say, 60 cm. deep in the case of a fosse of the size of that at Arbor Low. After the whole of the sides became completely sheltered in this way, the filling up to the present surface of the central parts of the ditch from natural causes would be the accumulation of centuries of finer material and stone washed in and blown in from the surrounding country. Until grass began to form on the vallum a more or less large proportion of the silting would be derived from the slipping and washing down of material from the higher ground. Finally, when the grass had begun to grow in the fosse, the silting would almost cease and the surface mould would gradually increase in thickness as vegetable matter decayed. This mould would probably form in an increasing ratio owing to the greater luxuriance of the grass caused by the greater depth of mould and the greater moisture in the centre of the ditch. It appears certain that these ancient ditches, as I have endeavoured to show, must have silted up (excepting the surface mould of course) in a constantly and greatly diminishing ratio.

Now the relative depths of these two Arbor Low arrow-heads does not appear to differ very remarkably when the formation of the talus is taken into consideration. The barbed arrow-head being on the *bottom* of the ditch and near the middle would become covered almost immediately the fosse was allowed to silt up. The other arrow-head being found within 3 to 5 cm. of the side of the ditch at a depth of 91 cm., it will be seen that it would be deposited on the talus and become covered very soon after the barbed arrow-head. On the other hand, the broken lozenge-shaped arrow-head was picked up out of the silting so very near the actual wall of the fosse that it is just possible it may have rested on a small ledge of the limestone rock, being removed therefrom by the pickaxe on the day of discovery. In any case it may be safely asserted that these arrow-heads were in use at about the same period, and that the forms were contemporaneous ; at any rate, this instance renders it obvious that the barbed or stemmed is not necessarily a later form of arrow-head than the lozenge or leaf-shaped form.

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[1] *Ancient Stone Implements of Great Britain*, 1872, p. 330.

As far as practicable, it was found desirable to remove the silting of the ditch layer by layer, or spit by spit ; and in this way relics from the upper spits were discovered and recorded before the lower parts were dug into, so that no error as to the depth of the 'finds' could possibly take place. The method generally adopted, I believe, and the easiest for the workmen, is to remove the material in an excavation to the bottom in one spot, and then under-pick the remainder of the material it is desired to remove, and let all the earth fall to the bottom of the excavation. Many of the relics in this way fall to the bottom of the hole before they are observed, and are recorded as being found at the bottom. This invariably and inevitably leads to error in assigning the various 'finds' to their proper *gisement*, and valuable evidence is not only lost in this way, but hasty and inaccurate conclusions are often arrived at on the merits (?) of unreliable records.

The Excavation of the Vallum.—In continuation of Section 4 across the fosse, a cutting, $3^{m}\cdot05$ wide, was made through the vallum on the north. At this point the crest of the rampart is about $1^{m}\cdot43$ above the 'old surface line' immediately below it. Like the section of last year through the vallum on the N.W., this cutting yielded no relics, but proved of interest, inasmuch as it was largely composed of huge boulders of limestone (maximum length $1^{m}\cdot22$) shown in the photographs. No doubt these boulders had been loosened in the formation of the fosse and utilised for the construction of the vallum. The N.E. face of this cutting was plotted in section on a scale of 60 to 1. Chert and calcite occurred in bands in the limestone strata here in large quantities, and fluor-spar was detected by Professor Boyd Dawkins.[1]

Two photographs of general views of Arbor Low taken this year show the more or less regular form of the vallum on the W. and S.W., and on the other hand the disturbance of the vallum on the S.E., caused not only by the constructors of the barrow on the vallum, but further by the state in which Bateman left the barrow after excavation in 1845. All along the crest of the eastern and N.E. vallum are irregular depressions, sufficient material for filling which may be observed at intervals in ledges and patches along the base of the inner side of the E. and N.E. vallum, or, in other words, along the outer edge of the fosse in these parts. The only feasible explanation for this seems to be that Mr. Bateman, elated by his success in finding a cist in the tumulus, pursued his investigations along the adjacent crest of the vallum at intervals and shovelled the material inwards down the slope of the vallum!

Trenching near the Stones.—Three excavations were made this year with a view to ascertaining whether holes existed in the limestone floor in which stones I., II., and XXXVII. originally stood, but still without satisfactory results. The various writers on Arbor Low disagree as to whether the stones originally stood in an upright position, or whether they always laid flat on the ground.[1] Isaacson declared that they were never placed in an erect position; Wilkinson and Pegge assert the reverse; Pilkington and Glover were 'uncertain'; Dr. Brushfield appears to be of opinion that the stones originally stood upright; Lord Avebury, writing some twenty-three years ago, stated cautiously, 'It is doubtful whether they were ever upright.'[2]

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[1] Professor Boyd Dawkins visited the excavations on June 2. Mr. Henry Balfour was the whole of the same day at Arbor Low, and a part of the next. On June 4 four members of the Derbyshire Archæological Society visited the diggings, including Mr. H. A. Hubbersty, Mr. W. R. Bryden, and Mr. W. J. Andrew, F.S.A.

The first hole, $2^{m}\cdot13 \times 1^{m}\cdot37$, was made to the east of and close to Stone XXXVII. There was a well-marked depression in the turf here, and the stone has a flat squared surface at the end. Just below the turf, depth 9 cm. (Plan 35), a small fragment of red pottery, apparently Romano-British, was found, and at 34 (plan and photograph) a small discoidal flint scraper, $31 \times 26\cdot5$ mm. and 7·7 mm. at its thickest part, yellowish-brown and translucent, was found in mould at a depth of 18 cm. It is worked all round the edges and on both faces, and in addition all over the bulb of percussion; in size and general character it resembles the small scrapers frequently found in association with Roman remains. A hole in the limestone floor certainly existed close to the N.E. of the stone, of more or less oblong form, length $1^{m}\cdot77$, maximum depth below surface of turf 64 cm. This hole, however, appeared to me merely one of the usual natural shallow depressions in the limestone, and the excavation afforded no evidence of a hole having been cut for the reception of the base of a standing stone.

Attention was now turned to the central stones, where a large patch of trenching, $10^{m}\cdot68 \times 2^{m}\cdot13$, was dug last year, resulting in the discovery of the extended human skeleton fully described by Dr. Garson and myself in last year's report. The S.W. face of Stone I. in the centre being bordered by a marked trench bounded again on the west by a slight bank or mound, an excavation $4^{m} \times 1^{m}\cdot50$ was next made. Digging had evidently taken place here in recent times, presumably by Bateman in 1845, when he opened the barrow on the vallum to the S.E. The rock was reached at a maximum depth of 61 cm. below the highest part of the turf and a minimum depth of 30 cm. Early Victorian shards were found, and a clay tobacco-pipe bowl, also nineteenth century; also a flint flake, depth 9 cm. at 36 on plan, and a fragment of blackish Romano-British pottery, depth 40 cm.

A third hole, $2^{m}\cdot44 \times 1^{m}\cdot37$ was made at the N.W. end of Stone II., maximum depth 76 cm., minimum depth 52 cm.. No evidence as regards the original position of this stone. Whether it ever stood upright, could not be adduced from this digging, and nothing was found but a flint flake at 38 on plan, at a depth of 15 cm. Time and funds did not permit of anything further being done in the 'centre.'

Excavations in the small Dyke connected with the Vallum of Arbor Low on the S.W.—The primary idea of excavation here was to ascertain whether the ditch of this small dyke, sometimes known as 'the Serpent,' continued under the rampart of the larger earthwork, and if possible to prove its age by means of any relics that might be found. The ditch on the surface is only marked by a very slight depression, and the rampart averages only 46cm. above the level of the surrounding field. Doubtless the bank was higher at the time of construction, but denudation has occurred and the lost material, gradually sliding down, has assisted in the formation of the silting of the ditch. A section, 2^{m}·13 wide, was first made through the bank and ditch at a point 51^{m}·85 from the centre of Arbor Low, and within the area of the plan. The finds in the ditch here were :—A small worked flint flake of yellowish-brown colour and translucent, depth 37 cm. (22 on plan and section); and a flint flake, depth 55 cm. (24 on plan and section). The bank yielded :—At 23 a doubtfully artificial black chert borer, depth 24 cm. At 27 (plan and section) depth 27 cm., on the level of the 'old surface line,' a well-formed greyish-white chert or flint end-scraper, maximum length 42 mm., width 36 mm., thickness 8 mm.; both faces are almost flat, and the bevelled edge of horse-shoe form is finely chipped, exhibiting signs of considerable use. At 30 (plan and section), depth 21 cm., a greyish flint or chert scraper, an end- and side-scraper combined; length 53 mm., width 30 mm., thickness at chipped and bevelled edge, 8 mm.; at the opposite end, that is, at the 'bulb' end, the implement had been finely worked to a point. This end and side were probably used for cutting purposes; the whole implement, and especially the finely chipped semicircular scraping end, is very smooth and worn, indicating prolonged use. These implements (Nos. 27 and 30) are undoubtedly of the date of construction of the dyke.

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[1] Stone XVI. of my plan at the present leans towards the N.E. at about 35° or 40° with the general turf level.

[2] *Journ. Brit. Arch. Assoc.*, vol. vi., new series, 1900, p. 131.

No further excavation of the bank was made, but the exploration of the ditch was extended for 1^{m}·37 to the north, and produced the following stone objects :—At 25 (plan and section) a long greyish-white chert flake, with rough and irregular serrations along both edges, depth 61 cm.; the oblique top does not appear to have been worked; the bulb of percussion displays a large and well-marked *éraillure.* At 26 (plan and section) at a depth of 98 cm. close to the bottom of the ditch, a small white flint or chert knife, finely chipped and of somewhat triangular form, length 30 mm., width 20·5 mm., greatest thickness 7 mm., was discovered. It is of an uncommon form, and at first sight would probably be included in the category of arrow-heads; it is, however, apparently a finished implement, being chipped all round the edges; the edge at base shows signs of crushing or bruising; one of the side edges is straight and neatly chipped, whereas the other is convex with a finely worked bevelled cutting-edge with signs of crushing near the base. On the other face the concave edge has been considerably worked; the bulb of percussion has also been chipped, leaving part of the *éraillure* facet visible. This is the most interesting implement found outside the vallum of Arbor Low during these explorations. Two flakes (not marked on plan) were also found here, both at a depth of 61 cm.: one is merely a long narrow outside flake, the other a flint flake with edges slightly serrated.

At this point the bank had been levelled down, probably for a modern cart-track, but it recommences and almost immediately terminates in the vallum of Arbor Low. Opposite to where this occurs another small excavation, 2^{m}·44 wide, was made of the ditch to determine whether it ended here or continued in a northerly direction under the vallum of Arbor Low. The ditch shelved up gradually, and the rock-end was found, as shown in a poor photograph outside the vallum, thus proving that this little earthwork is of the same period of construction as Arbor Low or later; but, judging from the relics discovered, it would appear to be of about the same date as Arbor Low itself. In this latter excavation a calcined chert scraper was found at a depth of

27 cm. (31 on plan and section): this implement, which was formed from an outside flake, has a pronounced and straight dorsal ridge, the section across the scraper being triangular. At 32 a small elongated narrow block chert end-scraper, worked also on both sides, was found, depth 49 cm.; and at 33 a black chert flake, depth 55 cm.

The average depth of this little ditch beneath the surface was 91 cm., the width at top $2^{m}\cdot 44$. The chief photograph of this digging taken from the south was unfortunately a failure, but the four sections have been levelled and plotted, scale 60 to 1.

Summary.—During the four weeks that the excavations have been in progress in 1901 and 1902 no metals have been found, nor any traces of fictile ware that could be assigned to the date of construction of Arbor Low. In all, six sections have been cut through the fosse, with extensions of Sections 2 and 4 to expose the solid sides of the northern causeway, $25^{m}\cdot 94$ of fosse in all; two cuttings have been made through the vallum; four patches of trenching of varying dimensions have been excavated in the interior, the primary idea of which work was to endeavour to find holes in which some of the stones could have stood; and of the small dyke to the S.S.W., $2^{m}\cdot 13$ of rampart and 6 metres of ditch have been examined. The number of relics found has certainly been disappointing, and yet, on the other hand, Arbor Low, not having been a habitation, and, from negative evidence, appearing not to have been a place of sepulture in the Stone Age, I do not know that more relics could be expected under the circumstances. Nothing Roman has been found, except three small fragments of what appears to be Romano-British pottery, just below the turf in the interior. As is well known, flint scrapers are frequently found in association with Bronze Age and Roman remains, but here they are found deep in the silting of the fosse, only in association with other rude stone implements and chipped flint arrow-heads of Neolithic form. The majority of the implements found appear to the naked eye to be of chert, which is only what one would expect, seeing that it is native, and an excellent substitute for flint, which had to be brought probably from some considerable distance. No polished implement or fragments have been discovered. Chipped celts and fragments are conspicuous by their absence.

Sir John Evans states that Mr. J. F. Lucas had a roughly chipped celt, 10 cm. long, from Arbor Low but no record of its *gisement* appears to have been preserved.[1] Sir John also mentions the finding of a rare form of circular knife[2] at Arbor Low in 1867, likewise in Mr. Lucas' collection; and in addition he figures a finely chipped flint blade,[3] 15 mm. long, found at Arbor Low in June 1865 (Lucas collection). Jewitt has engraved the same implement full size;[4] and this, with the circular knife already referred to, as well as a smaller knife of the same kind, 4·7 cm. in diameter, is now in the British Museum.

Arbor Low is therefore of such precise age as the barbed arrow-head may be assigned to, it having been found on the bottom of the deepest portion of the fosse. For reasons before stated, it has been shown that the barbed form of arrow-head does not necessarily and exclusively lead one to assign an earthwork in which such an arrow-head is found to the end of the Stone Age, or to the transitional period between it and the age when bronze was in general use. Judging from various finds of stone arrow-heads of the barbed form, although they are generally regarded as a late development in the Neolithic Age, they may probably have been in use in some districts about the middle of that age. The absence of finds on the old surface line under the vallum in the parts examined unfortunately does not help towards the solution of the problem of the date of construction of this fine circle of stones. Whilst still bearing in mind that Arbor Low has not been disproved to be of early Bronze Age date, no bronze, as before mentioned, has been found; so that the balance weighs in favour of Arbor Low being of Neolithic construction; but such a conclusion is, admittedly, only deduced on somewhat meagre evidence as regards the quantity and nature of the relics found. Finally, the evidence of Neolithic construction obtained last year has not been largely increased this year, but it has been greatly strengthened.

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[1] *Ancient Stone Implements*, 1872, p. 64.

[2] *Op. cit.*, p. 306.

[3] *Op. cit.*, p. 315, fig. 267.

[4] *Grave Mounds*, fig. 155.

It is unnecessary for the Committee to deal with the finds of this year in detail, as Mr. Gray has, in the preceding report, amply described the various objects discovered during the diggings. Undoubtedly the interest centres mainly round the finding of a typical 'tanged and barbed' flint arrow-head at the *bottom* of the fosse at a depth of over $1^{m}\cdot70$ below the present level of the silting. This form of arrow-head, being usually believed to be a *late* development in Neolithic flint working, points to the probability of the construction of the fosse and vallum not being referable to a date *earlier* than the late Neolithic period, and thus a time-limit in one direction seems to be fairly established. There were no indications that the arrow-head may have reached its position at a date long subsequent to the formation of the fosse. It is well known that the frequent use of implements, arrow-heads, scrapers, and the like of flint persisted far into the Bronze period, and to some extent even later, and that the 'tanged and barbed' type of flint arrow-head is very frequently found associated with Bronze Age finds. While, then, it must be admitted that the series of flint and chert implements discovered *in situ* at Arbor Low cannot claim *per se* to establish a Neolithic date for this monument, it should be borne in mind that the total absence of objects of bronze or other metal which characterised the finds of last year has persisted as a noteworthy feature of this year's results; and, in view of the extent of the area examined, this absence of metal has some significance.

If, on the one hand, the results so far obtained go to show that the construction of Arbor Low stone circle should probably not be referred to an *earlier* date than the later portion of the Neolithic period, there are reasons, on the other hand, for believing that it should not be placed *later* than the earlier portion of the Bronze Age. The absence of metal of any sort amongst the finds must be taken as a clue only at the value of *negative* evidence, but it may be a fair deduction, in the light of this evidence, that if bronze were in use at all at the time of construction there was at least no abundance of the metal, and that great care was exercised in avoiding the loss of pieces of metal during the work of digging the fosse and building the vallum, and this may perhaps of itself point to a time when the Bronze Age was in its infancy, and when metal was far scarcer and more precious than it became later on. A much more important piece of evidence, however, is that to which reference was made in the report of the Committee for last year, viz., that a Bronze Age tumulus was certainly constructed out of material *derived from a portion of the original structure* of the earthwork encircling the stone circle. For reasons given in last year's report, it seems fair to assume that the tumulus must be considerably later than the circle, and, in view of this piece of evidence, it is reasonable to assign the date of construction of the circle to a period *not later* than the *early* Bronze Age. If, as has been urged by some, the finds from the tumulus are themselves to be regarded as belonging to the *early* Bronze period, then the probability of the circle being of Neolithic date is much increased. The discovery of red-deer antlers in two portions of the fosse may point to their having been employed for purposes of excavation; a practice which was certainly a common one in Neolithic times. Unfortunately the fragmentary nature of the horns discovered prevents there being any certainty as to their having been so used, and their presence, while possibly having some significance, cannot be advanced as important evidence.

On the whole, therefore, the evidence so far acquired seems to indicate that the date of construction of Arbor Low stone circle should be located within the period covered by the Late Neolithic and Early Bronze periods. It would probably be unsafe, on the available evidence, to attempt a closer approximation, since the greater part of the monument still remains unexplored.

On Explorations at Knossos in Crete.—Report of the Committee, consisting of Sir JOHN EVANS (*Chairman*), Mr. J. L. MYRES (*Secretary*), Mr. A. J. EVANS, Mr. D. G. HOGARTH, Professor A. MACALISTER, *and* Professor W. RIDGEWAY. (*Drawn up by* Mr. A. J. EVANS.)

THE work at Knossos, which was begun on February 12 last and was continued until the end of June, has been fertile in results beyond all anticipation. It seemed at first destined to be rather a campaign of finishing up and of rounding off a fairly ascertained area. But besides the chambers that remained to be explored immediately contiguous to the Hall of the Double Axes and that of the Colonnades, excavated last year, the whole building was found to have a considerably larger extension on the eastern side than had been expected. The building was thus seen to have climbed down the slope in descending terraces to a point some 80 metres east of the northern entrance.

Considerable remains were uncovered of the eastern boundary wall, or rather of four separate walls in immediate contiguity to each other. The 'Hall of the Double Axes,' excavated last year, was found to have a double portico at its farther end facing both south and east. In the south wall of this *megaron* there had been visible last year a doorway leading to a finely paved passage with a 'dog's leg' turn so constructed as to ensure the privacy of the chamber beyond. The chamber thus approached has proved to be of quite original construction. It is flanked on two sides by a stylobate, which also served as a bench, between the pillars of which light was obtained, on the one side from a portico with two column-bases, on the other from an area the farther wall of which stepped back so as to ensure the better lighting of the chamber within. On the west side of this room is a balustrade, with an opening giving access to a small bath-chamber. Above the gypsum lining-slab of this bath-room a fine painted frieze of spirals and rosettes was found still clinging to the wall. Remains of a painted terra-cotta bath were found near.

Another interesting feature of the new *megaron* itself was a small private staircase in its north wall, leading up to the *thalamoi*, or bedrooms, above. Of the wall-paintings that had originally adorned the *megaron* and its columnar fore-hall some important remains were discovered, including quite an aquarium of fish, with parts of two dolphins. This discovery supplies the counterpart to the fine fish-fresco brought to light by the British school at Phylakopê, and the latter work must be now definitely recognised as a product of the Knossian school. One very characteristic feature is common to both works. As the different tones of blue had to be mainly reserved for the fish themselves, and in order to give them greater relief, the ground was left white, and the sea water gracefully indicated by azure wreaths and coils of dotted spray.

Here, too, was also found the upper part of a lady in a yellow jacket and light diaphanous vest, whose flying tresses suggest violent action. It had possibly belonged to a scene from the bull-ring. Another fragment found here shows a smaller female figure, nearly naked, springing from above and seizing the horn of a galloping bull like the figure from Tiryns. It has, moreover, been possible to put together a large part of a painted panel, found in 1901, giving a highly sensational scene from a Minoan circus show. A Mycenæan cowboy is seen turning a somersault over the back of a charging bull, to whose horns in front clings a girl in boy's costume; while another female toreador behind, in similar deshabille, stands with outstretched arms, as if prepared to catch her as she is tossed over the monster's back. The whole is a *tour de force* of the Minoan arena. Among other fresco remains were naturalistic foliage and lilies, and in a gallery east of the Hall of the Double Axes fine-veined imitations of marble blocks. A very suggestive piece of wall-painting, also found on this side, consists of a succession of mazes more elaborate than those on the later coins of Knossos, and showing that the prototype of the labyrinth in art goes back here to prehistoric times. Throughout all the region of the great south-east halls it has been possible to support a large part of the upper storey, and a most elaborate system of drainage has been found, including latrines with flush-pipes and drains of advanced construction, together with a succession of stone shafts descending from the upper floors to a network of stone conduits beneath the pavement of the lower rooms, large enough for a man to make his way along them. Removal of some later constructions has greatly modified the northern entrance passage, which now, with its massive western bastion, has a very stately appearance. Outside this have been brought out the remains of a considerable portico, including the bases of a series of large piers.

Large fresh deposits of inscribed tablets have come to light, the general purport of which was shown by the appearance of certain ideographic signs, such as swords and granaries, and those indicative of persons of both sexes. The largest deposit referred to percentages—some with the throne and sceptre sign before the amount—apparently recording the King's portion. A piece of a Mycenæan painted vase with linear characters, and two cups with inscriptions written within them in a kind of ink, supply wholly new classes of written documents. Great numbers of clay seal-impressions were also brought out, including a fragment of one stamped by a late Babylonian cylinder. In magazines below the later palace level, and belonging therefore to an earlier building, occurred seal-impressions with pictographic signs, a striking evidence of the anteriority of this system of writing on the palace-site of Knossos. Interesting new materials have also accumulated bearing on the metric systems employed, and even, it would seem, on the origin of coinage.

Among the finds of smaller objects two stand out respectively as of first-rate importance in the history of architecture and sculpture. One of these was the discovery of parts of a large mosaic consisting of porcelain plaques, a series of which represent the fronts of houses of two or three storeys. Fragmentary as most of these were, it was possible to reconstitute a fair number with absolute certainty, and thus to recover an almost perfect picture of a street of Minoan Knossos in the middle of the second millennium before our era. The different parts of the construction—masonry, woodwork, and plaster—are clearly reproduced, and the houses, some of them with two doorways, with windows of four and six panes—oiled parchment being possibly used for glass—are astonishingly modern in their appearance. Other plaques found with them show warriors and various animals, a tree, a vine, and flowing water, so that the whole seems to have been part of a large design analogous to that of Achilles' shield. The other find—made towards the close of the excavation—which throws a new light on 'the art of Daedalos,' is the discovery of remains of ivory figurines. These are carved in the round, the limbs being jointed together, and seem to have represented youths in the act of springing, like the cowboys of the frescoes. The life and balance of the whole, the modelling of the limbs, and the exquisite rendering of details, such as the muscles and even the veins, raise these ivory statuettes beyond the level of any known sculpture of the kind of the period to which they belong. The hair was curiously indicated by means of spiral bronze wires, and the amount of gold foil found with them suggests that they had been originally, in part at least, coated with gold—in which case they would have been early examples of the chryselephantine process. Some beautiful examples of goldsmiths' work were also found—a small gold duck with filigree work, a miniature gold fish exquisitely chased, and a spray resembling fern-leaves.

The new materials bearing on the local religion are extraordinarily rich. Remains of a miniature temple of painted terra-cotta, with doves perched above the capitals of columns, occurred in a stratum belonging to the pre-Mycenæan building. In the later palace a series of finds illustrated the 'bætylic' cult of the Double Axe and its associated divinities. A gem showed a female figure—apparently a goddess—bearing this sacred emblem. But more important still was the discovery of an actual shrine belonging to the latest Mycenæan period of the palace, with the tripod and other vessels-of-offering still in position before a base upon which rested the actual cult objects, including a small double axe of steatite, sacred horns of stucco with sockets between them for the wooden shafts of other axes, terra-cotta figures—cylindrical below—of a goddess, in one case with a dove perched on her head, and of a male votary offering a dove.

The actual discovery, within the palace walls, of a shrine of the Double

Axe must be regarded as a striking corroboration of the explorer's views as to its identification with the traditional labyrinth, and of the philological connection of the latter with the *labrys*, or double axe, arrived at independently by Max Meyer and Kretschmer on philological grounds.

One very important result of this year's excavations has been the discovery of a whole system of chambers and magazines below the level of the later building. This shows, as is also proved by the abundance of re-used blocks with more primitive signs, that an earlier palace had existed on the site. The magazines belonging to this earlier building were full of the remains of painted pottery belonging to the purer 'Kamares' class, and of finer fabric than the more transitional and later offshoots of the class found in some magazines brought to light this year in the south-east quarter of the second palace. Some of the earlier painted vases found in the magazines of this lower building are of an egg-shell-like fineness of fabric, an elegance of shape, and delicacy of colouring that was never certainly surpassed in the whole history of ceramic manufacture. Many are embossed in evident imitation of metal-work. We have here the proof of a highly developed 'Minoan' culture going back at least to the middle of the third millennium B.C.

Below this 'first palace' structure, again, the remains of the extensive Neolithic settlement that underlies the whole site everywhere came to light. A considerable harvest of stone implements, primitive pottery, and 'idols' of clay, marble, and shell was obtained from this Neolithic deposit. Fragments of obsidian vases derived from the first palace are of the Liparite type, unknown in the Ægean, and must have been imported from the Italian island.

Owing to the constant need of propping up the upper storeys and supporting terraces, much of the work has been of a difficult, and at times dangerous, nature, entailing a vast amount of actual construction in wood, stone, and brick. The shrine, like the Throne Room, had to be roofed over. Vast masses of earth had also to be removed from parts of the site, and nearly 250 workmen, including over a score of masons and carpenters, were constantly employed. Throughout the whole Mr. Evans had the devoted assistance of Dr. Mackenzie in superintending the excavation, and of Mr. Fyfe on the architectural and engineering side.

The excavation of the south-east corner of the palace has still to be completed, and some works of delimitation must be carried out in other directions. The search for tombs must certainly be renewed, and the lower palace strata have also still to be explored at several points, and more 'Kaselles' opened. Continued researches into the Neolithic deposit are also desirable, as well as the examination of some neighbouring buildings. Unfortunately the total amount that the Cretan Exploration Fund—including the British Association grant—was able to contribute towards the year's expenses has again fallen far short of what the explorer has found it necessary to expend.

[A fuller preliminary account of these excavations, with illustrations, will appear in the 'Annual of the British School of Archæology,' vol. viii., and a complete account of the whole Palace of Knossos in an independent volume eventually.]

Work of the Mammalian Heart.—Report of the Committee, consisting of Professor J. G. McKendrick (*Chairman*), Dr. T. G. Brodie (*Secretary*), *and* Professor W. H. Thompson, *appointed to study the Power of the Mammalian Heart for performing Work under varying External Conditions and under the Influence of Drugs.* (*Drawn up by the Secretary.*)

A series of experiments have been performed upon the mammalian heart isolated by a special method, in which the work is measured by recording the output of the heart when it is made to work against a constant pressure. It was found necessary to determine variations in the working capacity of the heart when the pressure against which it works varies, for this leads to an alteration in the flow through the coronary vessels which in turn leads to changes in the working capacity. The experiments of this class are not yet completed.

The influence of anæsthetics upon the isolated heart working against a constant pressure have also been investigated. Chloroform has a most marked depressant action upon the heart. The work performed falls in amount very rapidly, and may altogether cease. Ether has a preliminary stimulant action upon the heart, followed by a depressant effect. The depressant effect is never so marked as with chloroform, and with ordinary doses is only slight. Suprarenal extract has a most marked stimulant effect upon the isolated heart; it serves as a powerful antidote to the depressant action of chloroform. The experiments are still in progress.

The Micro-Chemistry of Cells.—Report of the Committee, consisting of Professor E. A. Schäfer (*Chairman*), Professor A. B. Macallum (*Secretary*), Professor E. Ray Lankester, Professor W. D. Halliburton, Mr. G. C. Bourne, *and* Professor J. J. Mackenzie. (*Drawn up by the Secretary.*)

The Committee beg leave to report as follows :—

1. The work of the previous year on the micro-chemical localisation of the oxidising ferments in the algæ was completed, and the results are now ready for publication.

2. A number of observations were made to determine if in the protophytan cell the calcium, potassium, sodium, and magnesium are in masked condition. For this purpose the larger-celled species of Spirogyra were employed, and the result was that the four elements mentioned were found in the ash from the cytoplasm, nucleus, and chromatophore of these organisms, as well as in the cell membrane; but it is only in the latter that they can be demonstrated during the life of the cell. Immediately on the occurrence of plasmolysis, or on killing the cytoplasm and nucleus, the potassium and the calcium can be indicated in the plasmolysed spherules and in the dead cytoplasm and nucleus. It is thus shown that during life these elements are combined in some manner which masks their presence. In regard to magnesium and sodium no conclusion could be reached, on account of the fact that for these elements there are no tests as distinct or as marked as those which serve for the micro-chemical

detection of potassium and calcium. It was also found that the iron present does not become demonstrable readily in dead nuclei or plasmolysed cells until they are allowed to undergo a long-continued decomposition in distilled water. This would seem to indicate that the combination which occurs in the case of calcium and potassium with the living matter is very different from that obtaining between the iron and the nucleo-proteid, chromatin. Everything points to the iron being a definite part of the nubleo-proteid compound during life. It is possible, on the other hand, to explain the masked condition of calcium and potassium during life as due to their existence as free ions protected by the living substance from the ordinary chemical reactions.

3. In relation to this investigation, but also as the result of an investigation on the composition of the Medusæ, *Aurelia* and *Cyanea*, in relation to the sea water in which they occur, it was found that the 'jelly' (or Mesoglœa of Bourne) in these forms is fundamentally an infinitesimally fine network of an albuminoid, 'discin,' in the mesh spaces of which are contained all fluid and salts derived from the sea water. The albuminoid as it exists in this network is distinct from inorganic substances, and alcoholic specimens of the 'jelly' when acted on by distilled water for several days give only a trace of ash. The mesoglœa is, therefore, in no sense a true jelly. It may be that the optical appearance of a network is really the expression of a foam-like structure, and that thus the 'jelly' is an emulsion ; but it is safer to compare it to the fibrin of clotted plasma. It is the disintegration of this network that is the cause of the liquefaction of the 'jelly' in the dead Medusæ.

These observations suggest that in animal and vegetable cells a similar disposition of the salts present may occur and the proteids holding their solutions, mechanically as in the mesoglœa, may be as inert as the 'discin' of the Medusæ. To express it differently, the cytoplasmic network in the living cell may be in many cases a result of the life of a cell, but not evidence of life in the cytoplasm.

4. Professor Mackenzie has been engaged on the investigation of the occurrence of masked iron and phosphorus in neoplasms, and reports that it will take some months yet to finish his observations.

The Committee ask to be reappointed.

Botanical Photographs.—Report of the Committee, consisting of Professor L. C. MIALL (*Chairman*), Professor F. E. WEISS (*Secretary*), Mr. FRANCIS DARWIN, *and* Professor G. F. SCOTT-ELLIOT, *appointed to consider and report upon a scheme for the registration of Negatives of Botanical Photographs.*

APPENDIX.—*Arrangements in Existence for the Preservation and Registration of Photographs of Anthropological and Geological Interest* . *page* 472

THE Committee recommend the formation of a register of photographs of botanical interest on similar lines to those already in existence for the registration of geological and anthropological photographs respectively (see Appendix).

To carry out such a scheme the Committee should be reappointed, with a small grant.

The Committee are of opinion that the following range of subjects should be included in the scheme :—

1. Portraits of any species of plant (more particularly foreign plants, grown under natural conditions), illustrating habit, natural surroundings, or points of morphological or physiological interest.
2. Diseases and malformations of plants.
3. Photographs of plants raised for purposes of experiment.
4. Photographs illustrating plant associations.

The Committee do not recommend at present the inclusion of photographs of histological preparations, nor do they consider that it would be desirable to include photographs of zoological interest in the same register with those of botanical interest.

APPENDIX

Arrangements in existence for the Preservation and Registration of Photographs of Anthropological and Geological Interest.

Both the Anthropological and the Geological Section of the British Association collect, preserve, and register prints of anthropological and geological interest respectively.

These are preserved, in the case of the geological photographs, in the Jermyn Street Museum; in the case of the anthropological photographs, also at some central institution.

The standard size for the geological photographs is whole plate, but other sizes are accepted. They are mounted on cards of uniform size and bound in albums. The anthropological photographs are mounted on cards of two sizes and filed, like card catalogue slips.

The photographs are arranged geographically, but a cross index of topics is also prepared. The card catalogue of the collection gives all necessary information as to locality, date, name of photographer, &c.

Negatives are either retained by the owner or deposited with a local photographer, who will supply prints at reasonable prices. The anthropological section has also made arrangements for the storage and insurance of any negatives deposited with them on loan.

No arrangements are made as to copyright. A detailed list of photographs received is published every year with the annual reports of the Committees, which states where the photographs may be obtained, and a copy of this report is sent to each donor.

Both Sections appoint Committees to carry out these schemes, and each Committee receives a small grant.

Investigation on the Respiration of Plants.—Report of the Committee, consisting of Professor H. MARSHALL WARD (*Chairman*), Mr. HAROLD WAGER (*Secretary*), Mr. FRANCIS DARWIN, *and* Professor J. B. FARMER.

THE 15*l.* allotted to the Committee was expended by Dr. Blackman on apparatus for investigating the relation between temperature and the assimilation of carbon dioxide.

The law which governs this relation has been worked out in his laboratory by Miss Matthaei, and the results are ready for publication.

The sum granted could, however, not be actually obtained this year, as by oversight application was not made to the Treasurer for it until a few days too late. The Committee therefore ask to be reappointed and to have the grant made last year again placed at their disposal.

Investigation of the Cyanophyceæ.—Report of the Committee, consisting of Professor J. B. FARMER (*Chairman*), Dr. F. F. BLACKMAN (*Secretary*), Professor MARSHALL WARD, *and* Mr. W. GARDINER.

THE investigation of the structure of the Cyanophyceæ has been continued by Mr. Harold Wager, and a paper dealing with the structure and constitution of the central body (nucleus) in species of Phormidium, Oscillaria, Tolypothrix, and Cylindrospermum will be brought before Section K at the Belfast meeting.

A portion of the grant has been expended in apparatus, and the Committee recommend that they be reappointed, and ask for a further grant of 40*l.* in order that Mr. Wager may be enabled to purchase a high-power objective for the continuance of his investigations, especially into the minute structure of the central body.

Teaching of Elementary Mathematics.—Report of the Committee, consisting of Professor FORSYTH (*Chairman*), Professor PERRY (*Secretary*), Professor CHRYSTAL, Mr. W. D. EGGAR, Mr. H. W. EVE, Professor GIBSON, Dr. GLADSTONE, Professor GREENHILL, Professor R. A. GREGORY, Professor HENRICI, Professor HUDSON, Dr. LARMOR, Professor A. LODGE, Sir O. LODGE, Professor LOVE, Major MACMAHON, Professor MINCHIN, Sir A. W. RÜCKER, Mr. ROBERT RUSSELL, *and* Professor S. P. THOMPSON, *appointed to report upon improvements that might be effected in the teaching of Mathematics, in the first instance in the teaching of Elementary Mathematics, and upon such means as they think likely to effect such improvements.* (*Drawn up by the Chairman.*)

APPENDIX.—*Two Suggested Schedules of Experimental Geometry* . . *page* 478

IN submitting their present report, the Committee desire to point out that this is not the first occasion on which the British Association has attempted to deal with the teaching of elementary mathematics. About thirty years ago a similar body was appointed to consider a part of the subject, viz., 'the possibility of improving the methods of instruction in elementary geometry'; and two reports were presented, one at the Bradford meeting in 1873 (see the Report, volume for that year, p. 459), the other at the Glasgow meeting in 1876 (see the Report, volume for that year, p. 8).

The two reports advert to some of the difficulties that obstruct improvements in the teaching of geometry. One of these is alleged to be 'the necessity of one fixed and definite standard for examination purposes'; apparently it was assumed that this fixed and definite standard should not merely be required from all candidates in any one examination, but also be applied to all examinations throughout the country. In order to secure the uniformity thus postulated, the Committee, thinking that no text-book had been produced fit to succeed Euclid in the position of authority, and deeming it improbable that such a book could be produced by the joint action of selected individuals, suggested the publication of an authorised syllabus. In their second report they discussed the merits of a particular syllabus—that of the Association for the Improvement of Geometrical Teaching; but, in spite of such commendation as was then expressed, the syllabus has not been generally adopted.

It is still true that (in the words of the former Committee) 'in this country at present teaching is guided largely by the requirements of examinations.' For some time to come the practice of the country is not unlikely to allow examinations to retain at least a partial domination over teaching in schools. Accordingly, if the teaching is to be improved, it seems to be a preliminary requisite that examinations should be modified; and, where it is possible, these modifications in the examinations should leave greater freedom to the teacher, and give him more assistance than at present.

On the other hand, there is a tendency in this country whereby, in such matters as teaching and examination, the changes adopted are only gradually effected, and progress comes only by slow degrees. Accordingly, the general recommendations submitted in this report are such that they can be introduced easily and without any great alteration of the best present practice. It is the hope of the Committee that the recommendations, if adopted, will constitute merely the first stage in a gradual improvement both of teaching and of examinations. For the most part only broad lines of change are suggested: this has been done in order to leave as much freedom as possible to teachers for the development of their methods in the light of their experience.

Is Uniformity imperative?

The Committee do not consider that a single method of teaching mathematics should be imposed uniformly upon all classes of students; for the only variations then possible would be limited by the individuality of the teacher. In their opinion, different methods may be adopted for various classes of students, according to the needs of the students; and corresponding types of examination should be used.

It is generally, if not universally, conceded that a proper training in mathematics is an important part of a liberal education. The value of the training depends upon the comprehension of the aims of the mathematical subjects chosen, upon the grasp of the fundamental notions involved, and upon the attention paid to the logical sequence of the arguments. On the other hand, it is freely claimed that, in the training of students for technical aims such as the profession of engineering, a knowledge of results and a facility in using them are more important than familiarity with the mathematical processes by which the results are established with rigid precision. This divergence of needs belongs, however, to a later stage in the training of students. In the earliest stages, when the elements of mathematics are being acquired, the processes adopted can be substantially the same for all students; and many of the following recommendations are directed towards the improvement of those processes.

Teaching of Practical Geometry.

The former Committee recommended (and the present Committee desire to emphasise the recommendation) that the teaching of demonstrative geometry should be preceded by the teaching of practical and experimental geometry, together with a considerable amount of accurate drawing and measurement. This practice should be adopted, whether Euclid be retained or be replaced by some authorised text-book or syllabus, or if no authority for demonstrative geometry be retained.

Simple instruments and experimental methods should be employed exclusively in the earliest stages, until the learner has become familiarised with some of the notions of geometry and some of the properties of geometrical figures, plane and solid. Easy deductive reasoning should be introduced as soon as possible; and thereafter the two processes should be employed side by side, because practical geometry can be made an illuminating and interesting supplement to the reasoned results obtained in demonstrative geometry. It is desirable that the range of the practical course and the experimental methods adopted should be left in large measure to the judgment of the teacher; and two schedules of suggestions, intended for different classes of students, have been submitted to the Committee by Mr. Eggar and Professor Perry respectively, and are added as an Appendix to this Report.

Should there be a Single Authority in Geometry?

In the opinion of the Committee it is not necessary that one (and only one) text-book should be placed in the position of authority in demonstrative geometry; nor is it necessary that there should be only a single syllabus in control of all examinations. Each large examining body might propound its own syllabus, in the construction of which regard would be paid to the average requirements of the examinees.

Thus an examining body might retain Euclid to the extent of requiring his logical order. But when the retention of that order is enforced, it is undesirable that Euclid's method of treatment should always be adopted; thus the use of hypothetical constructions should be permitted. It is equally undesirable to insist upon Euclid's order in the subject-matter; thus a large part of the contents of Books III. and IV. could be studied before the student comes to the consideration of the greater part of Book II.

In every case the details of any syllabus should not be made too precise. It is preferable to leave as much freedom as possible, consistently with the range to be covered; for in that way the individuality of the teacher can have its most useful scope. It is the competent teacher, not the examining body, who best can find out what sequence is most suited educationally to the particular class that has to be taught.

A suggestion has been made that some Central Board might be instituted to exercise control over the modifications made from time to time in every syllabus issued by an examining body. It is not inconceivable that such a Board might prove useful in helping to avoid the logical chaos occasionally characteristic of the subject known as Geometrical Conics. But there is reason to doubt whether the authority of any such Central Board would be generally recognised.

Opinions differ as to whether arithmetical notions should be introduced into demonstrative geometry, and whether algebraic methods should be used as substitutes for some of the cumbrous formal proofs of propositions such as those in the Second Book of Euclid: for opinions differ as to the value of strictly demonstrative geometry, both for training and for knowledge. Those teachers who do not regard algebraic methods as proper substitutes for geometrical methods might still use them, as well as arithmetical notions, for the purpose of illustrating a proposition or explaining its wider significance. It is the general opinion of the Committee that some association of arithmetic and algebra with geometry is desirable in all cases where this may be found possible; the extent to which it may be practised will depend largely upon the individual temperament of the teacher.

Every method of teaching demonstrative geometry has to face the difficulties inevitably associated with any complete and rigorous theory of proportion. In the opinion of the Committee, not merely is Euclid's doctrine of proportion unsuited for inclusion in elementary work, but it belongs to the class of what may be called university subjects. The Committee consider that the notion of proportion to be adopted in a school course should be based upon a combination of algebraical processes with the methods of practical geometry.

Examinations in Geometry.

As regards examinations in geometry, the Committee consider that substantial changes in much of the present practice are desirable. In most, if not in all, of the branches of mathematics, and especially in geometry, the examination ought to be arranged so that no candidate should be allowed to pass unless he gives evidence of some power to deal with questions not included in the text-book adopted. Such questions might comprise riders of the customary type, arithmetical and algebraical illustrations and verifications, and practical examples in accurate drawing and measurement. The Committee consider the latter of particular importance when the range is of an elementary character; some influence will be exercised upon the teaching, and some recognition will be given to the course of practical geometry that should be pursued in the earlier stages.

Arithmetic and Algebra.

The Committee are of opinion that, in the processes and explanations belonging to the early stages of these subjects, constant appeal should be made to concrete illustrations.

In regard to arithmetic, the Committee desire to point out what has been pointed out so often before, that, if the decimal system of weights and measures were adopted in this country, a vast amount of what is now the subject-matter of teaching and of examination could be omitted as being then useless for any purpose. The economy in time, and the advantage in point of simplification, would be of the greatest importance. But such a change does not seem likely to be adopted at present; and the Committee confine themselves to making certain suggestions affecting the present practice. They desire, however, to urge that teachers and examiners alike should deal with only those tables of weights and measures which are the simplest and of most frequent practical use.

In formal arithmetic, the elaborate manipulation of vulgar fractions should be avoided, both in teaching and in examinations; too many of the questions that appear in examination papers are tests rather of mechanical facility than of clear thinking or of knowledge. The ideas of ratio and proportion should be developed concurrently with the use of vulgar fractions. Decimals should be introduced at an early stage, soon after the notion of fractions has been grasped. Methods of calculation, accurate only to specified significant figures, and, in particular, the practice of contracted methods, should be encouraged. The use of tables of simple functions should be begun as soon as the student is capable of understanding the general nature of the functions tabulated; for example, the use of logarithms in numerical calculation may be begun as soon as the fundamental law of indices is known.

In regard to the early stages of algebra, the modifications (both in teaching and in the examinations) which are deemed desirable by the Committee are of a general character.

At first, the formulæ should be built on a purely arithmetical foundation, and their significance would often be exhibited by showing how they include whole classes of arithmetical results. Throughout the early stages, formulæ and results should frequently be tested by arithmetical applications. The arithmetical basis of algebra could be illustrated for beginners by the frequent use of graphs; and the practice of graphical processes in such cases can give a significance to algebraical formulæ that would not otherwise be obtained easily in early stages of the subject.

In passing to new ideas, only the simplest instances should be used at first, frequent reference still being made to arithmetical illustrations. Advance should be made by means of essential development, avoiding the useless complications of merely formal difficulties which serve no other purpose than that of puzzling candidates in examinations. Many of the artificial combinations of difficulties could be omitted entirely; the discussion of such as may be necessary should be postponed from the earlier stages. Teachers and examiners alike should avoid matters such as curious combinations of brackets; extravagantly complicated algebraic expressions, particularly fractions; resolutions of elaborate expressions into factors; artificially difficult combinations of indices; ingeniously manipulated equations: and the like. They have no intrinsic value or importance; it is only the mutual rivalry between some writers of text-books and some examiners that is responsible for the consideration which has been conceded to such topics.

General Remarks.

If general simplification either on these or on similar lines be adopted, particularly if graphical methods are freely used, it will be found possible to introduce, quite naturally and much earlier than is now the case, some of the leading ideas in a few subjects that usually are regarded as more advanced. Thus the foundations of trigonometry can be laid in connection with the practical geometry of the subject-matter of the Sixth Book of Euclid. The general idea of co-ordinate geometry can be made familiar by the use of graphs; and many of the notions underlying the methods of the infinitesimal calculus can similarly be given to comparatively youthful students long before the formal study of the calculus is begun.

APPENDIX.

Two Suggested Schedules of Experimental Geometry.

(*Scheme submitted by* Mr. Eggar, *chiefly Geometrical, on Euclidean Lines.*)

Accurate measurements of lines, angles, areas, and (if possible) volumes, should precede any formal definitions. The following suggestions are intended for the earliest stages.

Instruments.—Hard pencil, compasses, dividers, straight-edge graduated in inches and tenths, and in centimetres and millimetres; protractor (if rectangular, its connection with the division of the circle should be carefully pointed out); set-squares (45° and 60°); notebook of squared paper; tracing paper; scissors and loose paper for cutting out and folding.

It is important that careful draughtmanship and the use of properly adjusted instruments should be insisted on. All constructions should be drawn in fine pencil lines. Inaccurate work, or work done with soft or blunt pencils, should receive very little credit.

Processes.—Test of a straight line; intersection of two lines; notion (not definition) of a point; measurement of a length; estimation of the second place of decimals of inches or centimetres; use of set-squares for drawing parallel lines; construction and measurement of angles from 0° to 360° by the use of a protractor; limits of error in setting off angles; test of a right angle; test for accuracy of set-squares: their use in drawing perpendiculars.

The drawing of parallels and perpendiculars by the aid of compasses; the bisection of angles and straight lines; construction of triangles from given dimensions; the fundamental properties of triangles verified and illustrated by drawing; similar triangles; the division of lines into equal parts and into parts in given proportion; test of equality of angles by the superposition of the angles of similar (not equal) triangles by means of tracing paper.

The construction of rectangles, parallelograms, and quadrilaterals, from adequate data; notion of a tangent line; construction of tangents to circles, using drawing-office methods; notion of a locus; construction of circles satisfying given conditions; verification of the properties of circles.

Measurement of area; use of squared paper; area of an irregular figure found by counting the number of squares.

Illustrations of propositions relating to the areas of squares, rectangles, parallelograms, and triangles. Calculation of these areas from given dimensions (*e.g.*, base and altitude), and verification by squared paper.

The length of the circumference of a circle determined experimentally (*e.g.*, by rolling a coin with an ink mark on its rim down an inclined sheet of paper, or by wrapping a strip of paper tightly round a cylinder, pricking the paper where it overlaps, unwrapping and measuring the distance between the two marks); the area of a circle determined by squared paper.

The area of a rectangular sheet of paper can be calculated from measurements in inches and in centimetres, and hence the number of square centimetres in a square inch can be obtained by division. To how many places of decimals may the result be regarded as accurate?

Construction of paper models of solids to illustrate the notions of surface and volume.

Measurement of volume should be illustrated by cubical bricks. Cubes of 1 inch and 1 centimetre can be obtained cheaply. Volumes of rectangular solids, prisms, cylinders, and cones should be measured where possible, and the results verified by displacement of water if access to a physics laboratory is to be had. Measurements of area and volume form a useful introduction to the notion of an algebraic formula.

As a pupil advances in elementary algebra, geometrical illustrations may be employed with advantage, *e.g.*, the verification with squared paper of the formulæ corresponding to the propositions of Euclid, Book II., graphs, the solution of quadratic equations with ruler and compasses.

(*Scheme submitted by* Prof. PERRY*: this Scheme is intended to accompany a Course of Arithmetic, Algebra, and Experimental Science.*)

Practice in decimals, using scales for measuring such distances as 3·22 inches, or 12·5 centimetres.

Contracted and approximate methods of multiplying and dividing numbers; using rough checks in arithmetical work; evaluating formulæ.

Mensuration.—Testing experimentally the rule for the length of the circumference of a circle, using strings or a tape measure round cylinders, or by rolling a disc or sphere, or in other ways; inventing methods of measuring approximately the lengths of curves; testing the rules for the areas of a triangle, rectangle, parallelogram, circle, ellipse, surface of cylinder, surface of cone, &c., using scales and squared paper; propositions in Euclid relating to areas tested by squared paper, also by arithmetical work on actual measurements; the determination of the areas of an irregular plane figure (1) by using Simpson's or other well-known rules for the case where a number of equidistant ordinates or widths are given; (2) by the use of squared paper when equidistant ordinates are not given, finding such ordinates; (3) weighing a piece of cardboard and comparing with the weight of a square piece; (4) counting squares on squared paper to verify rules. Rules for volumes of prisms, cylinders, cones, spheres, and rings, verified by actual experiment; for example, by filling vessels with water, or by weighing objects of these shapes made of material of known density, or by allowing such objects to cause water to overflow from a vessel.

The determination of the volume of an irregular solid by each of the three methods for an irregular area, the process being first to obtain an irregular plane figure in which the varying ordinates or widths represent the varying cross-sections of the solid; volumes of frustra of pyramids and cones; computation of weights from volumes when densities are given.

Stating a mensuration rule as an algebraic formula. In such a formula any one of the quantities may be the unknown one, the others being known. Numerical exercises in mensuration. The experimental work in this subject ought to be taken up in connection with practice in weighing and measuring generally, finding specific gravities, illustrations of the principle of Archimedes, the displacement of floating bodies, and other elementary scientific work. A good teacher will not overdo this experimental work: he will preserve a proper balance between experimental work, didactic teaching, and numerical exercise work.

Use of squared paper.—The use of squared paper by merchants and others to show at a glance the rise and fall of prices, of temperature, of the tide, &c. The use of squared paper should be illustrated by the working of many kinds of exercises, but it should be pointed out that there is a general idea underlying them all. The following may be mentioned:—

Plotting of statistics of any kind whatsoever of general or special interest; what such curves teach; rates of increase.

Interpolation, or the finding of probable intermediate values; probable errors of observation; forming complete price-lists by manufacturers; finding an average value; areas and volumes as explained above.

The plotting of simple graphs; determination of maximum and minimum values; the solution of equations. Very clear notions of what we mean by the roots of equations may be obtained by the use of squared paper.

Determination of laws which exist between observed quantities, especially of linear laws.

Corrections for errors of observation when the plotted quantities are the results of experiment.

Geometry.—A knowledge of the properties of straight lines, parallel lines, right angles, and angles of 30°, 45°, and 60°, obtained by using and testing straight-edges and squares; dividing lines into parts in given proportions, and other experimental illustrations of the Sixth Book of Euclid; the definitions of the sine, cosine, and tangent of an angle, and the determination of their values by graphical methods; setting out of angles by means of a protractor, when they are given in degrees or radians, also (for acute angles) by construction when the value of the sine, cosine, or tangent is given; use of tables of sines, cosines, and tangents; the solution of a right-angled triangle by calculation and by drawing to scale; the construction of any triangle from given data; determination of the area of a triangle. The more important propositions of Euclid may be illustrated by actual drawing. If the proposition is about angles, these may be measured in degrees by means of a protractor, or by the use of a table of chords; if it refers to the equality of lines, areas, or ratios, lengths may be measured by a decimal scale, and the necessary calculations made arithmetically. This combination of drawing and arithmetical calculation may be freely used to illustrate the truth of a proposition. A good teacher will occasionally introduce demonstrative proof as well as mere measurement.

Defining the position of a point in space by its distances from three co-ordinate planes. What is meant by the projection of a point, line, or a plane figure, on a plane? Simple models may be constructed by the student to illustrate the projections of points, lines, and planes.

The distinction between a scalar quantity and a vector quantity; addition and subtraction of vectors; experimental illustrations, such as the verification by the student himself of the triangle and polygon of forces, using strings, pulleys, and weights.

The Teaching of Science in Elementary Schools.—Report of the Committee, consisting of Dr. J. H. Gladstone (*Chairman*), Professor H. E. Armstrong (*Secretary*), Lord Avebury, Professor W. R. Dunstan, Mr. George Gladstone, Sir Philip Magnus, Sir H. E. Roscoe, Professor A. Smithells, *and* Professor S. P. Thompson.

The introduction of the Block grant, in place of the former Examination grants in Elementary Day Schools, deprives your Committee of the opportunity of giving the usual statistical data as to the number of children receiving instruction in scientific subjects. The loss of this interesting information is, however, more than made up by the satisfaction of knowing that the teachers are now more free to adopt true educational principles than when they were trammelled by the necessity of preparing their scholars for an official examination, on the result of which the financial position of the school would be dependent.

One of the returns of the Board of Education does, however, afford some indication of the measure of attention given to certain subjects as compared with others. According to this the number of departments in which subjects of a more or less scientific character are taken are as follows, though the number of scholars is no longer given (the numbers are for schools in England and Wales):—

Algebra	1,266
Euclid	105
Mensuration	387
Mechanics	366
Chemistry	185
Physics	109
Elementary Physics and Chemistry	152
Animal Physiology	413
Hygiene	34
Botany	138
Principles of Agriculture	20
Domestic Economy or Domestic Science	1,076

These correspond with what were formerly known as specific subjects of instruction.

In the case of the Evening Schools your Committee are able to continue the tabular statement for another year. Though the total given is somewhat larger than in the two years immediately preceding, it will be noticed that in Mathematics and Physics there is a general falling off, the only increases worth noting being in those subjects that may be more appropriately designated 'applied science.'

Both the Day and the Evening Schools are now passing through a crisis in their history, and may be regarded as in a transition state. The Day Schools under School Boards are adversely affected by the regulation of the Board of Education, limiting the age of scholars to fifteen years. There were 3,697 scholars of fifteen years and upwards in the year ending August 31, 1901. The corresponding numbers were 4,146 in 1898, 3,817 in 1899, and 3,828 in 1900. The Evening Schools under the same authority are not allowed to give instruction to adults except with the consent of the County Council or the County Borough Council, as the case may be, and that consent, if given, is limited to the current school year. In the majority of cases that consent has been freely given, though in some instances schools have had to be closed in consequence of the consent being withheld. The uncertainty as to the future is a great cause of discouragement both to the managers of schools and to the scholars.

Science Subjects	Number of Scholars				
	1896–97	1897–98	1898–99	1899–1900	1900–1901
Euclid	1,036	1,525	1,216	1,601	1,384
Algebra	7,467	9,996	7,432	7,247	6.188
Mensuration	27,388	29,966	24,369	23,090	22.192
Elementary Physiography	3,712	4,807	4,213	3,552	2,943
Elementary Physics and Chemistry	3,135	2,902	3,116	3,497	3,316
Domestic Science	—	117	142	471	303
Science of Common Things	10,910	13,874	11,499	11,418	11,892
Chemistry	5,658	6,590	5,963	6,704	6,542
Mechanics	1,365	1,129	987	1,252	1,050
Sound, Light, and Heat	726	813	437	305	313
Magnetism and Electricity	3,834	3,967	3,005	3,244	2,949
Human Physiology	5,865	6,237	4,296	4,619	4.312
Hygiene	3,179	4,062	3,276	3,228	3,908
Botany	692	763	597	718	747
Agriculture	2,355	2,300	1,826	1,847	1,937
Horticulture	1,001	1,354	1,350	1,511	1,846
Navigation	68	37	46	118	175
Ambulance	9,086	13,030	12,980	14,838	18,764
Domestic Economy	19,565	23,271	19,915	18,968	19,343
Totals	107,042	126,740	106,665	108,228	110,104

There have been no changes of importance in the code of regulations for Day Schools, but that for Evening Schools has been remodelled much more on the lines of the South Kensington branch of the Board of Education, and it is issued from that office, as these schools are now regarded by the Government as giving Secondary Education.

The Higher Elementary Schools, for which special provision was made two years ago, have not to any large extent superseded the Higher Grade Schools which had been previously established in most of the large towns. The additional grants offered have scarcely proved to be an equivalent for the increased cost of conducting these schools, and this fact, coupled with the stringent regulations imposed, has discouraged the transfer of the Higher Grade Schools.

The exhibitions which have been held this summer in London by the London School Board and the Nature-Study Exhibition Association indicate the progress of practical work in science, especially in the region of Physics and Biology. The School Board has sought to encourage the making of scientific apparatus by the science masters and their scholars out of ordinary and inexpensive materials, as more instructive than the mere manipulation of purchased articles; and the exhibition of what has been thus produced in the schools during the last twelve months shows a very marked advance, both in quantity and quality, over that of the preceding year. The exhibits—651 in number—ranged over Botany, Chemistry, Heat, Light, Hygiene, Magnetism and Electricity, Mathematics, Mechanics, Natural History, Physiography, Physiology, Sound, and Steam. The

Board has also entered into arrangements with the custodians of the Royal Parks for a weekly supply of cut flowers, leaves, &c., to furnish illustrations of the reading lessons as well as material for the scientific study of Botany. The Nature-Study Exhibition Association has been organised for the purpose of creating an interest in biological studies and of illustrating the most approved methods of arranging school museums and other appliances for teaching. The Exhibition consisted of a large collection of objects gathered by children in their own neighbourhoods, and of drawings which they had made from the plants and animals themselves, and of manuscript notes as to their development. These illustrations were generally given in their proper colours, and often with the aid of the microscope. The Exhibition was made still more valuable by a series of conferences conducted by ladies and gentlemen who have given special attention to Nature study.

On the Conditions of Health essential to the Carrying on of the Work of Instruction in Schools.—Report of the Committee, consisting of Professor C. S. SHERRINGTON (*Chairman*), Mr. E. WHITE WALLIS (*Secretary*), Mr. E. W. BRABROOK, Dr. C. W. KIMMINS, Professor L. C. MIALL, *and* Professor H. L. WITHERS.

THE Committee had co-operating with them in their investigations and deliberations the valuable assistance of Dr. C. Childs, Dr. Clement Dukes, Miss Findlay, Miss Ravenhill, Dr. Rivers, Mr. J. Russell, and Dr. Sydney Stephenson.

In all methods adopted for carrying on the work of instruction in schools health conditions must be recognised as an essential principle, seeing that in most cases the greater part of a child's day is spent within the influence of the school, and no teaching can be considered successful unless so arranged that the health of the scholars may be properly maintained.

The health conditions relating to school life which appeared to the Committee to be appropriate for consideration include :—

1. Bodily nourishment.
2. Clothing.
3. Housing of children in schools.
4. The working of the bodily functions and organs of sense.
5. Physical exercise.
6. The apportionment of time to work and rest, including length of lessons and holidays.
7. Healthy tone of mind and morals.
8. Preventive and precautionary measures against infectious diseases.

It was not considered practicable to deal with all of these subjects in the first report, and it was therefore decided to direct attention to the following points :—

A collection and tabulation of records of original observations on the periods of day appropriate for different studies, the length of lessons, and periods of study suitable for children of different ages.

A collection and tabulation of anthropometrical and physiological observation forms in use in various schools with a view to preparing a typical form for general use.

A collection and tabulation of anthropometrical and physiological observations recorded in different schools for a series of years on the same children.

A collection and tabulation of recorded investigations into the causes of defective eyesight in school children and a definition of the conditions necessary for preserving the sight.

An inquiry into the practical knowledge of hygiene possessed by school teachers.

For this purpose several sub-committees were appointed, and the following information has been collected :—

ANTHROPOMETRICAL AND PHYSIOLOGICAL OBSERVATIONS.

The sub-committee appointed to collect and tabulate anthropometrical and physiological forms in use in various schools with a view to preparing a typical form for general use, and to collect and tabulate anthropometrical and physiological observations recorded in different schools for a series of years on the same children, report as follows :—

An application to the schools from which information was furnished to the Anthropometric Committee in 1878–1883 has given the following results :—

At Eton College Dr. Warre informs the Committee there has not been any systematic collection of information since 1883, and that no forms are in use for the purpose.

At Westminster School Dr. Gow informs the Committee that no anthropometrical observations are taken, but he expresses the opinion that they ought to be made, and the Committee hope that the presentation of this report may lead to their being undertaken.

At Radley College measurements are taken in the following form :—

Radley College Gymnasium.

1st Measurements and Date when taken…………						2nd Measurements and Date when taken …					
Age	Height	Weight	Girth of Chest *a.* inflated *b.* normal	Fore-arm	Upper Arm	Age	Height	Weight	Girth of Chest *a.* inflated *b.* normal	Fore-arm	Upper Arm
years	ft. in.	st. lb.	inches	inches	inches	years	ft. in.	st. lb.	inches	inches	inches
			a.						*a.*		
			b.						*b.*		

At Felsted School, Essex, the form adopted is as follows :—

Number	Names (arranged in alphabetical order)	Height (in stockings)		Weight (in trousers only)		Chest (standing naturally, army measurement)
		feet	inches	stones	lb.	inches

Dr. Edwyn B. Trow has kindly furnished the Committee with the record from January to April 1902, when 211 boys were observed. They give an average of 5 feet 3⅛ inches in height, 7 st. 9 lb. in weight, and 31⅛ inches chest girth, ranging from minima of 4 feet 4⅛ inches, 4 st. 2 lb., 24½ inches to maxima of 6 feet 4 inches, 12 st. 2 lb., 40 inches respectively ; but as the ages are not specified these figures cannot be used for comparison. This will appear from the cases in which the minima and maxima occur as follows :—

	ft.	in.	st.	lb.	in.
A . . .	4	4⅛	4	11	25¾
B . . .	4	4⅛	6	13	26½
C . . .	4	4¼	4	2	25½
D . . .	4	5	4	7	24½
E . . .	5	6½	10	10	40
F . . .	6	4	12	2	36

which leads to the inference that the differences are due to age. F has the maximum both in height and weight.

In Bootham School, York, anthropometrical measurements have been taken regularly six times every year (*i.e.*, at beginning and end of every term) since January 1896, and Mr. A. L. Dawes has kindly furnished the Committee with a copy of the form used as follows :—

Anthropometrical Measurements.

Name ....

—	End of Term	Beginning of Term	A Year ago
Age (years, months) . .			
Height (feet, inches) . .			
Weight (pounds) . . .			
Chest expanded (inches) . .			
Chest contracted (inches) .			
Forearm (inches) . . .			
Upper Arm (inches) . . .			

Signed ....

Date ....

At the Hampstead School of the King Alfred School Society (founded 1897, incorporated 1898) the following is the form adopted :—

Medical Report.

Name:			*Date:*			
Age:						
Weight:						
Height:						
Head Measurements:						
Chest Girth:						
Chest Expansion:						
Mouth:						
Sight:						
Hearing:						
Nose:						
Nutrition:						
Nervous Signs:						
Remarks:						

The most important and systematic collection of anthropometric statistics in a school of which the Committee are aware is that made in Marlborough College. The master has kindly furnished the Committee with copies of the annual reports of the Marlborough College Natural History Society from the year 1884 (except that of 1890, which is out of print), which contains each year a return of the number, name, form, age, height, weight, chest girth, circumference of head, leg, and arm, and of the increase in each since the last measurement. In later years the chest has been measured both expanded and contracted. Mr. Mayrick, by whom this great work has been superintended for many years, observed that the full expansion of the chest is easy to get, but the full contraction is not so easy; if, however, the chest be emptied by an audible continued expiration, it is easy to tell by the sound when the limit is reached. A column is given showing the difference between the expanded and contracted chest. This is a measure of the capacity of the effective respiration, and the greater the difference the higher is the efficiency of the breathing apparatus, and probably the vital energy is greater in proportion. This index by no means necessarily rises with the age, and is, in fact, sometimes unexpectedly high in young boys. The age is recorded in years and months, not in decimals of a year; the height is given in inches and decimals of an inch; the weight in pounds to within half a pound only; the chest measurement in inches and decimals. The Report of the Anthropometric Committee presented to the British Association in 1880 contains a series of tables founded on the observations taken in Marlborough College from 1874–1878 on height, weight, chest girth, head girth, arm girth, and leg girth. It would be desirable to continue that tabulation to the present time, but that would be a work of very great labour and not inconsiderable expense.

In the North London Collegiate School for Girls a lady medical inspector has been appointed since 1887, especially with a view to determining the kind of physical exercises that are suitable in different cases, and that official has established a system of anthropometric observations which is more than usually complete. Mrs. Sophia Bryant, D.Sc., the head mistress, has kindly furnished the Committee with a copy of the form in use, which is as follows:—

Name .... *No.* ....

	Age (years)					
	Height (inches)					
	Weight (lb.)					
Head	Antero-posterior diameter	(centimetres)				
	Transverse diameter					
	Circumference					
	Vault					
Eyes	Vision Right					
	Vision Left					
	Astigmatism Right					
	Astigmatism Left					
	Colours					
Chest	Circumference (inches)					
	Condition of lungs					
	Condition of heart					
	Vital capacity (cubic inches)					
	Circumference of	(inches)				
	Stays waist					
	Vest waist					
Muscular Power	Power of grasp Right	(lb.)				
	Power of grasp Left					
	Power of back muscles					

Medical Inspector's Notes.	Secretary's Notes.

The forty-fourth report of the Inspector of Reformatory and Industrial Schools in Great Britain, Mr. J. E. Legge ('Parliamentary Paper,' cd. 840, p. 54), contains a physical census of boys and girls in those schools taken in July 1901. The superintendents in industrial schools were asked to furnish the height, weight, and chest measurement of all boys, and weight of all girls, between the ages of eleven and twelve and fourteen and fifteen. These ages were selected because they were convenient for comparison with the statistics published by the Anthropometric Committee in 1883. The height was taken without boots, the weight in clothes but without boots, and the chest girth with the chest empty. The results with some important comments upon them will be found in the Blue-book referred to, and the Committee are glad to know that Mr. Legge contemplates calling for a similar return in 1903, when the boys and girls who were between the ages of eleven and twelve will have reached that which was the higher age in the previous census, and then a double comparison may be effected. The Committee have been favoured by Mr. Legge with an expression of his strong opinion that inquiries of this sort are far more likely to get results if the particulars asked for are few and the apparatus to be used perfectly simple and as little like a laboratory instrument as possible. In asking merely for height, weight, and chest measurement he obtained those particulars from practically everybody he applied to, so that minor inaccuracies were checked by the great mass of figures (3,679 boys, 1,246 girls) he had to deal with. Had he asked for arm-stretch, force of resistance, and nervous tests, he might not have obtained one-tenth as many returns, and those with greater difficulty. The following is the form he used :—

Reformatory School.

Boys between 14 *and* 15.

Height (without boots), weight (in clothes, but without boots), chest measurement (over shirt, but with chest empty).

Name or Number	Town or Country from which sent	Height (without boots)	Weight (in clothes, but without boots)	Chest (over shirt, but with chest empty)
		ft. in.	lb. oz.	in.

Thus far with regard to the collection of anthropometric observations in schools. With regard to the practical application of them and the deductions to be made from them, the Committee desire to draw attention to an excellent paper on the physical examination and development of public schoolboys read before the medical officers of Schools Association on April 4, 1899, by Mr. Cecil Hawkins, of Haileybury College. Taking the records of over 40,000 observations and adopting a modification of Mr. Francis Galton's plan of percentiles, the author has constructed diagrams showing from each year of age, from eleven to eighteen, a series of twenty curves of growth, increase of weight, and increase of chest girth. The application of these diagrams is simple and effective where periodical observations of the same individual are kept. Thus an example is given of a boy who for three successive half-yearly periods was in the curve numbered nineteen, next to the lowest in respect alike of height, weight, and girth. In the fourth half-yearly period he was up to the eighteenth curve in height; in the fifth he reached the seventh in weight and the eighteenth in girth. In the seventh he gained a place on the seventeenth curve for height and the sixteenth for weight. In the eighth he fell back a little, receding to the eighteenth curve in weight and the nineteenth in girth; but in the ninth he recovered, rising one step in each. This example and others, given in the same paper, show that by means of these curves an exact demonstration of the physical history of each individual may be made. They lead to the consideration of another point which is within the reference to this Committee—that is, the necessity for physiological observations. Where the statistics are treated in this method, showing a fall and recovery in the relative conditions of growth, it is evident that the cause of such fall and the conditions of such recovery ought to be sought for. The Committee are therefore of opinion that the plan adopted by Mrs. Bryant of leaving a space for the medical inspectors' notes is desirable, and that in that space should be entered any event in the history of the person under observation affecting his general health.

Subject to this observation the Committee attach weight to the recommendation of Mr. Legge, and, while desiring that, wherever practicable, a more extended series of observations should be set on foot, such as that at Marlborough College and the North London College for Girls, cannot resist the conclusions that for schools generally a simple record of height, weight, and chest girth is all that can be expected. For the purpose of keeping the record of each individual and dealing with it upon the ingenious method devised by Mr. Hawkins, the card system would be found very convenient.

The following form of card is suggested:—[1]

School, . Date, . 19 .
Initial or Register No. of scholar, . Sex, . Age, years months.

Weight and Measurements.

Weight in indoor school costume, without shoes . . lb. oz.
Height, without shoes . . . . in. quarters.
Chest girth at nipple line when fully expanded, the pupil standing upright, with chin elevated and eyes directed horizontally forward . . . . . . in.

Observations.

Mouth { Teeth .
Tongue .
Palate .
Eyes Snelling's letter test (in full daylight) .
Nose { Breathing .
Adenoids .
Nerve signs { Face .
Hands .
Body .
Posture .
Medical inspectors' notes. .

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[1] Suggestions made by a Committee previously appointed are given in the Report of the Oxford Meeting, 1894, p. 439.

KNOWLEDGE OF HYGIENE POSSESSED BY SCHOOL TEACHERS.

In order to obtain the information desired it was decided to send a circular letter to some of the chief School Boards, training colleges, and public schools in the United Kingdom; also to certain private schools and high schools, and other societies and institutions engaged in education. The circular letter contained questions framed for the purpose of obtaining information with regard to the practical knowledge of hygiene possessed by school teachers.

This letter was sent to fifteen public schools, four high schools, four private schools, two Church schools, eight School Boards in the United Kingdom, also to the Board of National Education of Ireland (Dublin), thirteen training colleges, two polytechnics, five societies connected with teaching, and to certain educationists.

Replies were received from eight public schools, eight School Boards, four training colleges, and two other institutions.

In answer to the questions contained in the circular letter it was elicited :—

(1. Are any certificates in hygiene for teachers recognised in your schools ?)

That certificates in hygiene were recognised (*a*) in only one private school; (*b*) in all the eight Board schools; (*c*) and in only three training colleges from whom answers were received; but none were recognised in the eight public schools nor in the high schools that replied.

(2. What certificates in hygiene have you found most suitable to the requirements of teachers ?)

That the following certificates connected with the health subjects were those held by the teachers or recognised as a qualification :—

The Certificate of the Science and Art Department in Hygiene (Board of Education); Certificate of the British College of Physical Training; the College of Preceptors' Associate and Licentiate Diplomas; the Certificate in Hygiene of the National Board of Education in Ireland; the Certificate of the Sanitary Institute in Practical Hygiene for School Teachers. The examination for this last-named certificate appears to be the only one in which the teacher's practical knowledge is tested by an oral examination.

In those schools in which no certificate in hygiene for teachers are recognised the teachers have received no systematic instruction in the subject at all.

(3. If the teachers with whom you are connected have not been prepared for any special certificate in hygiene, have they received any instruction in it or dealt with the subject at all, and, if so, in what manner ?)

In those schools in which no certificates in hygiene for teachers are recognised the teachers have received no systematic instruction in the subject at all.

(4. To what extent are teachers required to exercise their knowledge of the subject ?)

a. The teachers in eight of the schools are expected to exercise their knowledge to a slight extent in the management of the school building.

In all the others the management is left to the head master or head mistress or to medical officers and nothing is required of the teachers.

b. The arrangements of the curriculum are for the most part left to the head master or head mistress with occasional discussions with the staff.

c. The physical training and drill are apparently conducted by the teachers in the Board schools and partly by specialists in other schools.

d. In three of the largest School Boards teachers are expected to make systematic observations of the pupils' health, eyesight, defects, &c., under the guidance of specialists.

In other reports the methodical observations seem to be simply confined to inspection by the teachers for cleanliness and signs of infectious diseases or entrusted to a limited extent to the medical officer, or to be altogether ignored.

(5. What opportunities and encouragements are afforded to the teachers for the study of mental and moral as well as of physical hygiene ?)

In some few schools periodical meetings are held at which mental and moral school hygiene are dealt with in addresses and discussions, but there is no other evidence of the matter being treated as important.

In addition to the replies to the circular, reports on the subject have also been received from the Dublin Board of National Education and the London School Board, with notes by Dr. Kerr. These reports contain valuable information but are too long to quote in full, and are therefore summarised in the following notes.

The Report of the Commissioners of National Education, Dublin, shows :—

That about three hundred and fifty teachers hold special certificates in hygiene granted to them by the Commissioners : Hygiene and Domestic Economy for the female teachers, Elementary Science, School Discipline, Physical Drill (into which questions of hygiene largely enter) for the male teachers.

Teachers are required to attend to the ventilation of schoolrooms at least three times a day, to take charge of the offices, &c., and see that these are kept in proper order. The arrangement of the curricula does not depend upon the teachers, and the methodical observation of the children is limited to personal cleanliness. The dozen good books on hygienic subjects sanctioned by the Commission for use in National Schools includes the 'Temperance Lesson Book' (Richardson). The programme of instruction issued to managers and teachers calls special attention to the need of the lessons in cookery and laundry work being made the occasion for imparting sufficient information on hygienic matters. The object lessons and elementary science are well planned, working from the child's point of view, but the list of the optional subjects does not include hygiene.

The Report of the School Board for London shows—

That the only qualification in hygiene generally recognised by the School Board for London is the advanced certificate of the South Kensington Branch of the Board of Education, already referred to in Miss Ravenhill's report. Papers taken at random of one hundred teachers applying for promotion showed that seventy had taken this certificate.

Teachers are also required to obtain the Board's physical education certificate, but are exempt from the theoretical part if they have already taken the advanced hygiene. The British College of Physical Education grants a certificate for male and female school teachers; a certificate on the Swedish system is also granted by that College for women teachers. Both of these are regarded as fulfilling the Board's requirement.

The Board also recognises in special cases the certificate of the Sanitary Institute as an alternative to the advanced hygiene certificate of the Board of Education.

The head teacher of each department of a school is responsible for seeing that the regulations as to school hygiene are carried out with regard to cleanliness, ventilation, keeping temperature of class-rooms at sixty degrees, supervision of offices, &c.

The Board have recently arranged for eight oculists to make an inspection of the children's eyesight, and teachers are instructed to place blackboards in a good light and to write large upon them; also to study the children's eyesight when at needlework.

Remarks by Dr. KERR.

(*a*) Female teachers generally are utterly indifferent to the question of ventilation. Many of the older teachers are opposed to any opening of windows.

(*b*) Most teachers resist the sufficient breaking up of lessons, and do not interpose short drills, desk exercises, and rests as they should, especially with younger children, in such continuous exercise of special nerve-centres as is involved in writing lessons. They are much prone to adopt new methods without understanding principles, and the results are frequently caricatures of what is really wanted.

Infant teachers seem to use most common sense in relation to their work, probably through the influence of Froebel Child Study and other such Societies.

(*c*) In many parts of the country there is little or no physical drill or training in Pupil Teacher centres. All such centres ought to have this subject insisted on: the drill they want is more elaborate than ordinary school work, and marks awarded for drill, general carriage, and deportment. The bearing, carriage, and general behaviour of pupil teachers has a decided influence (subconsciously) on their children. A report to the Bradford School Board last November deals with the inferior physical condition of pupil teachers at central classes.

(*d*) Most teachers only look on these matters as they are likely to affect their school results. They will look after mouth breathers when they realise the effectual result of surgical treatment educationally. They do not take the trouble, and cannot be trusted to conscientiously carry out eyesight testing (probably it is so exceedingly uninteresting and monotonous, the immediate results are not apparent, and the reasons for its importance they fail to realise).

(*e*) A few teachers enter into every educational question with avidity, and in most cases they find in towns plenty of means of following up subjects in which they are interested. Hygiene as a part of every teacher's equipment should be insisted on, and have equal marks with art. It would greatly add to the teachers' interest in their work.

Notes by Miss Ravenhill.

Most certificated teachers have 'got up' the subject from some text-book in order to take the Science and Art Department 'Elementary Hygiene' certificate. This is usually found practicable after fifteen or twenty hours' memorising of statements. A considerable number of teachers attend a course of instruction which, almost without exception, consists of theoretical lectures, sometimes illustrated with a few experiments, occasionally by models, but more often only by diagrams.

There is little or no evidence of any practical application of the information acquired, and no linking it with the formation of habits, either—

(1) in the regulation of individual life and personal health ;
(2) in the schools or class-rooms where daily work is carried on ;
(3) in the lessons given to the children, should such be included in the time-tables.

For this I account by the following reasons :—

(*a*) The force of habit, which leads to unquestioned acceptance of what is (*i.e.*, of a low standard of health, of bad conditions for work, &c.).

(*b*) The absence of training in the application of school or college studies to the problems of life. Hitherto most subjects have been memorised for teaching purposes, rather than studied to form character and to influence action.

(*c*) The want of encouragement from inspectors or school authorities, themselves frequently deficient in appreciation of the great importance of hygiene in school life. Suggestions on sanitary reforms or requests for amendment of faulty conditions by well-informed teachers are not unusually met with indifference, occasionally even by unpleasant rebuffs and hints that a repetition of such interference will mean a 'black mark' against its author's name.

(*d*) The deadening effect of work carried on under pressure, often under unwholesome conditions of air, which reduces energy to a minimum.

(*e*) The English point of view that 'someone else' is responsible ; and that the efforts of one solitary individual must be futile—therefore to make them is useless.

My experience shows these teachers to be quickly aroused to a profound self-sacrificing interest in, and appreciation of the importance of hygiene. Their enthusiasm makes them active in the desire to apply such knowledge as soon as they grasp the fact that opportunities for doing so exist. They are delighted also with the educational possibilities the subject affords, but they find themselves checked and their hands tied by the attitude of their authorities. Speaking generally, little encouragement is given to pursue the study with thoroughness ; no special incentive is as yet offered for its practical acquirement ; while the prevalent ignorance of what constitutes school hygiene among authorities, the fact that *l. s. d.* must be their first consideration in the supposed interests of the ratepayers, and the custom of entrusting the care and regulation of school buildings chiefly to untrained caretakers, limits very seriously a teacher's opportunities for direct application of hygienic knowledge.

Official References to the Possession of an Acquaintance with Hygiene on the part of Elementary Teachers.

(1) Article 101, Day School Code, 1901, requires managers and teachers 'to satisfy the inspector that all reasonable care is taken in the ordinary management of the school to bring up the children in habits of punctuality, of good manners and language, of cleanliness and neatness, and also to impress upon the children the importance of cheerful obedience to duty, of consideration and respect for others, and of honour and truthfulness in word and act,'—but no special reference is made to the formation of healthy habits as such.

(2) Among 'Notes on Articles of the Code of 1901,' in the 'Revised Instructions applicable to the Code of 1901,' the following appears under Article 15, III. :—

'Household management, including cookery, laundry work, and practical housewifery, is recognised in the Code as a subject of instruction, and a grant is made for it. As it is a wide subject requiring a thorough knowledge, not only of the practical work of a house and its management, but of elementary hygiene and physiology, it is necessary that the teacher should be well grounded in these subjects.'—There is no suggestion how she is to acquire this knowledge.

3. In 'Specimen Scheme 6 for a Girls' School' (Revised Instruction, 1901), lessons on air, ventilation and respiration, water, washing and cleaning, food, drinks, and the management of health are included, and presuppose capacity on the part of the teacher to give such instruction.

4. *King's Scholarship Examination Syllabus.*—Until December 1901 this included domestic economy for girls; the regulations and syllabus for 1902 omit any reference to, or inclusion of, domestic economy, physiology, or hygiene in the girls' studies.

5. *Regulations and Syllabus for Acting Teachers' Certificate Examination for* 1903.—Subject 7, theory of teaching, B. (2), contains the following dealt with theoretically :—'School hygiene, ventilation, heating and temperature, overcrowding, posture, play and games, cleanliness and appearance, signs of fatigue in children, influence of health on efficiency of work, unhealthy children, common signs of depressed health, pallor, wasting, ophthalmia, stunted growth, neglected children, underfeeding, children requiring special attention, crippled children, mental deficiency, real and apparent. Apparent deficiency due to malnutrition, irregular attendance, errors of vision and deafness. Onset of acute diseases requiring immediate removal—rashes, sickness, swellings, feverishness, irritability, fits.'

Subject 11 (for women acting teachers). General elementary science offers candidates a choice of three subjects :—

A. Physiography :—

  I. Elementary.
  II. Advanced.

B. Elementary biology :—

  (*a*) General.
  (*b*) Plant life.
  (*c*) Animal life.

C. Domestic science and general hygiene, of which the syllabus is as follows :—

Domestic Science and General Hygiene.—Work and rest, exercise, habits, recreation, food, its composition, purity and preparation, its transformation and destination within the body, dietary, water-supply and cleanliness, fresh air and heating, clothing, materials and their selection.'

Candidates are not expected to master the whole of these subjects, and may choose those which their opportunities of study and observation or their special tastes render suitable, but they are all required to take elementary physiography (A). Consequently the number who will study C is quite uncertain, and in any case the subject is treated in a very restricted manner.

I hope to procure later on some information as to what is finally required of certificated teachers.

It should also be noted that the Education Act of 1898, Clause 3, relating to the inspection of secondary schools, states that the inspection should be for the purpose of ascertaining the provisions made for the teaching and health of the scholars.

Notes from Schools in the United States.

Department of Education, City of New York.

Answering your questions in the order in which you state them, I beg to say, in answer to question No. 1, that physiology and hygiene are taught systematically in high schools ; physical culture and care of heating and ventilating apparatus are taught theoretically and practically.

In answer to question No. 2 I beg to say that teachers are held responsible for the heating and ventilating conditions in their class-rooms.

In answer to question No. 3, Yes.

In answer to question No. 4 I beg to say that physicians, under the direction of the Department of Health, visit the schools daily for the purpose of making examination of the pupils. The sanitary conditions of the buildings are looked after by inspectors appointed by this department and also by local superintendents.

(Signed) WILLIAM H. MAXWELL,
City Superintendent of Schools.

Cleveland Public Schools.

1st. We give quite detailed attention to the teaching of the subject of hygiene through our teachers in our City Normal School, which is both theoretical and practical, though largely the former.

2nd. Our teachers are held responsible for the care of their rooms in respect to all immediate hygienic conditions, including temperature, ventilation, and other matters which come under their notice.

3rd. They are not only permitted to make statements in regard to sanitary defects or arrangements of time-tables, but they are required to do so whenever they have special views upon these matters.

4th. We have had recently appointed a supervisor of physical education and sanitary conditions of the schools. It is his province, in addition to his work in supervision of gymnastics, to make suggestions on all points included in the sanitation of school buildings. We think we have made great progress in five years in these matters.

(Signed) L. H. JONES,
Superintendent of Instruction.

'School Hygiene' in German Training Colleges.
Note by Mr. M. E. SADLER.

Reference to instruction in hygiene is made in the regulations for Prussian training colleges, both for elementary and secondary school teachers. In the case of the former it is required that 'in the instruction given to the student as to the administration of his office he shall be made acquainted with the demands of school hygiene.' The secondary school teachers in training are liable to be called upon 'to write short essays on matters connected with the principles of school hygiene.' In neither case is there any prescribed syllabus, and the extent to which such study is pursued will vary with local circumstances. The many excellent text-books (*e.g.*, Eubenberg and Bach, Baginsky-Janke) written in part, if not wholly, by teachers prove the great interest taken in such matters by members of the teaching profession. Nevertheless there exists in some quarters a desire for the introduction into the training-college course of a much more definite scheme of study.

CONCLUSION.

The information so far collected indicates that school authorities very imperfectly realise how important for school life is that applied knowledge of the several sciences which constitutes modern hygiene.

School authorities are content to allow teachers to remain ignorant in respect to this knowledge; or they are content to accept from them as evidence of sufficient knowledge certificates which guarantee a merely superficial and second-hand acquaintance with the subject, not asking for any assurance of practical insight into or experience of the facts and problems of hygiene in its application to school life. Encouragement should be given to those teachers and school-workers who, learning by the heuristic method by observation, experiment, comparison, and contrast in personal and in school life, are bringing about healthier mental and moral conditions in school children as well as better physical conditions.

The careful consideration and scientific and practical application of health conditions in all arrangements connected with education and school life in elementary and secondary and especially also in public schools is of such vital importance to the effective well-being and progress of the nation that the Committee urge the British Association to memorialise the Education Department—

1. To adopt or recognise some more thorough and practical test of a teacher's knowledge and experience of the application of health conditions in school life.
2. And further to protect health in school life by making practical knowledge of hygiene as applied to school life an essential qualification for those to whom it entrusts school inspection.

The Committee desire to be reappointed, and ask for a grant of 10*l.* in order to continue their inquiry.

TRANSACTIONS OF THE SECTIONS.

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SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

PRESIDENT OF THE SECTION—Professor JOHN PURSER, M.A., LL.D., M.R.I.A.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

IN opening our proceedings to-day allow me at the outset to express my deep sense of the honour the Association has conferred upon me in asking me to preside over this Section.

My predecessors in this Chair have usually given you a survey of some department of Mathematics or Physics, tracing what had been already accomplished in that department and indicating the nature of the problems which still awaited solution.

May I crave your indulgence if I deviate from this course and, following the suggestion of some of my friends, take the opportunity of the Association meeting on Irish soil to give you a slight historical sketch of our Irish School of Mathematics and Physics?

In attempting such a review, for the sake of brevity as well as for other reasons, I shall confine it to the work of those who are no longer with us, and I would not carry it further back than the beginning of last century. This seems a natural starting point, as there was at that time a very marked revival of the study of science in the University of Dublin, a revival largely due to the influence of Provost Bartholomew Lloyd.

Lloyd won his Fellowship in Trinity College a few years before the century opened, and subsequently filled in succession the Chairs of Mathematics and Natural Philosophy. In both departments he imported a radical change into the methods of teaching. By his treatises on Analytical Geometry and on Mechanical Philosophy he introduced the study of what was then called the French Mathematics, in other words the more advanced Analytic Methods, which were in use on the Continent. In 1831 he was appointed Provost of the College, and his tenure of the office, though brief, was signalised by many important improvements and new developments effected in the University teaching.

Dr. Bartholomew Lloyd was President of one of the earliest Meetings of this Association, that held in Dublin in 1835.

His son, Dr. Humphrey Lloyd, had a course which was a singularly close parallel to his father's.

He won his Fellowship in 1824, and succeeded his father in the Chair of Natural Philosophy. He also was afterwards appointed Provost, and he too presided over another Dublin Meeting of this Association, that held in 1857. He also, in this again following in his father's steps, wrote important works on different branches of Physics; 'Light and Vision,' a systematic treatise on plane as distinct from physical optics, 'Lectures on the Wave Theory of Light,' and lastly a treatise on 'Magnetism.'

It is, perhaps, in connection with this latter subject that his most important work was done. He made in association with Sabine an elaborate series of observations on terrestrial magnetism in twenty-four stations in various parts of Ireland, and when subsequently, at the instance of this Association and of the Royal Society, the Government established magnetic observatories in different parts of the world, it was Lloyd who was entrusted with the task of drawing up the manual of instructions for the observers and of receiving their reports.

In the interval between the two Lloyds another name claims attention. Dr. Romney Robinson occupied during an exceptionally long life a much honoured and influential position amongst men of science. It was in this city he received his early education, for when young Robinson was only nine years of age his father had occasion to move to Belfast, and he placed his son under Dr. Bruce, a well-known schoolmaster of those days. Robinson was afterwards sent to Trinity College, and after a distinguished course was elected to a Fellowship in 1814. For some years he lectured in college as Deputy Professor of Natural Philosophy. He relinquished his Fellowship on obtaining a College living, and a few years later was appointed Astronomer in charge of the Armagh Observatory. The results of his observations were considered so valuable as to be used by the German astronomer Argeländer in determining the proper motions of stars. The range, however, of his published papers was by no means confined to Astronomy, but extended to the most varied subjects, Heat, Electricity, Magnetism, Turbines, Air-pumps, Fog-signals, and others. He is best known to the general public as the inventor of the Cup Anemometer. He was chosen to preside over the Birmingham Meeting of this Association in 1849.

Robinson was intimately associated with Lord Rosse and keenly interested in the experiments which culminated in the construction of the great reflector in Parsonstown. This naturally leads us to speak of Lord Rosse himself. Few scientific achievements took a greater hold upon the public mind than the successful completion of his great telescope. Only those who have read in Lord Rosse's own papers the description of the many difficulties he had to contend with in forging and polishing that wonderful speculum, harder than steel yet more brittle than glass, can adequately appreciate the patience and resource with which those difficulties were successively overcome.

Of the results obtained with this instrument the most notable were in the observation of the Nebulæ, a department where its unsurpassed power of light-concentration came fully into play. No doubt at the time public attention was most excited by the resolution of a number of hitherto supposed nebulæ into star clusters, leading to the premature conclusion in the minds of those less instructed that all the nebulæ might ultimately be so resolved. To us, however, a far greater interest attaches to the observation of the structure of what we now know to be genuine nebulæ, especially the great discovery that these had in many cases a peculiar spiral form. All previous telescopes had failed to detect this spiral character; but the drawings taken by Lord Rosse and his assistants put this feature beyond question, and these have been fully confirmed in recent years, when more accurate delineations were obtained by photography. I need not dwell upon the significance of this form, indicating, as it does, a rotatory movement in these mighty masses and fitting in with, if not actually confirming, Laplace's Nebular Hypothesis.

Sir William Rowan Hamilton was undoubtedly the most striking figure in the annals of the Dublin School of Mathematics. *In limine* we must make good our right to call him an Irishman, for his greatest admirer and disciple, Professor Tait, has claimed him for a countryman of his own, asserting that Hamilton's grandfather was a Scotchman who migrated to Dublin with his two young sons. That this was a complete misconception has been abundantly proved by the careful investigations of his friend and biographer, Dr. R. P. Graves, who shows conclusively that the only known strain of Scotch blood in Hamilton came through his grandmother, who was the daughter of a minister of the Church of Scotland.

It is interesting to find how early Hamilton's remarkable mental powers began to show themselves. Dr. Graves has given us a letter from his mother in which she writes to her sister of the marvellous precocity of her little four-year-old boy, telling how 'he reads Latin, Greek, and Hebrew.'

His mental development did not belie these early indications, for at the age of thirteen, thanks to the teaching and care of his uncle, who was a most extraordinary linguist, he had not only acquired a considerable knowledge of the classics and the modern European languages, but also attained some proficiency in Arabic, Sanscrit, and Persian. His mathematical studies, on the other hand, appear to have been carried on without help from anyone, and it is noteworthy that he does not seem to have used common text-books, but to have gone direct to the great original authors; *e.g.*, he read his algebra in Newton's 'Arithmetica Universalis'; while at the age of fifteen he set himself to read the 'Principia,' and two years later began a systematic study of Laplace's 'Mécanique Céleste.' His own estimate of his powers may be gathered from a characteristic letter to his sister written just after he had entered Trinity College:—

'One thing only have I to regret in the direction of my studies, that they should be diverted—or rather rudely forced—by the College course from their natural bent and favourite channel. That bent, you know, is science—science in its most exalted heights, in its most secret recesses. It has so captivated me, so seized on, I may say, my affections that my attention to classical studies is an effort and an irksome one; and I own that, before I entered College, I did not hope that in them I would rise above mediocrity. My success surprised me, but it has also given me a spur by holding out a prospect that even in the less agreeable part of my business I may hope still to succeed.'

This letter is interesting as indicating on Hamilton's part a consciousness wherein lay his real strength and vocation. Not that his interest in literature ever abated. To the last he loved to try his hand at poetical composition, frequently inserting in his letters to his friends sonnets of his own.

He knew Wordsworth intimately, and the poet to whom he sent some of his productions gives him the following candid advice:—

'It would be insincere not to say that something of a style more terse and a harmony more accurately balanced must be acquired before the bodily form of your verses will be quite worthy of their living souls. You are perfectly aware of this, though perhaps not in an equal degree with myself; nor is it desirable you should be, for it might tempt you to labour which would divert you from subjects of infinitely greater importance.'

Hamilton was first in his College classes in every subject and at every examination, and it was fully expected that he would carry off both the medals in Mathematics and Classics at his Degree when the following circumstances suddenly changed all his plans. Dr. Brinkley, the Professor of Astronomy in the University, was appointed to a Bishopric, and Hamilton, though still an undergraduate, was invited to offer himself for the vacant Chair. Sir George Airy and more than one of the Fellows of Trinity were also candidates, but Hamilton was unanimously elected.

His career as an original author dates from this time, for immediately after his appointment he communicated to the Royal Irish Academy the first of three remarkable papers on 'Systems of Rays.'

Two striking features may be observed in these papers, as indeed in all his scientific memoirs: the generality and comprehensiveness with which he states his object at the outset and the confidence with which he follows the bold and original lines of treatment which he lays down for himself, and closely connected with this, the determination not to be baffled by any laboriousness of calculations which the application of his method may involve him in. In his first paper he begins by examining what happens to a system of rays of light emanating from a point and subjected to any number of reflections at curved surfaces. He establishes the theorem that such a system will be cut orthogonally by a system of surfaces, the length of the path measured from the original source to any of these surfaces being the same for all the rays. The proof he gives of this theorem is so simple that it now seems almost axiomatic; but it is curious that Malus, who had made the laws of Light his special study, though he suspected that the theorem ought to hold, yet found himself unable to establish it.

Hamilton, now considering the length of the path to any point as a function of the coordinates of that point, and denoting this function by V, proves that V satisfies a simple partial differential equation of the first order and proceeds to show the important part the function V plays in the theory.

He goes on to prove generally that if we are dealing, not with right lines, that is, with paths, for which as between any two points $\int ds$ is a minimum, but with curved paths for which $\int \mu ds$ is a minimum (where μ is a function of the coordinates), and a system of such paths be drawn through a given point, O, the system of surfaces V = const. will still cut all the paths at right angles. If we adopt the emission theory of Light, and we take for μ the velocity of Light, V becomes 'the Action,' and the minimum property which the paths satisfy is the principle of 'Least Action.' If, on the other hand, we adopt the undulatory theory, and we take for μ the reciprocal of the velocity, the minimum property becomes the principle of 'Least Time.' Thus Hamilton shows that, by altering the significance of μ, his method applies to either theory.

Introducing the further conception that μ depends, not only on the coordinates of the point, but also on the direction-angles of the ray, he is able to apply his reasoning to rays passing through a crystal. He gives by his method a new and interesting proof of the equation of Fresnel's wave-surface, and arrives at the conclusion, hitherto unnoticed by mathematicians, that this wave-surface possesses four conical cusps and also four special tangent planes, each of which touches the surface, not in one point only, but in an infinite system of points lying in a circle. The physical significance of these theorems is what is known as Conical Refraction.

Having drawn this inference from his mathematical analysis, Hamilton wrote to his friend Dr. Lloyd and asked him to verify it by actual observation, and accordingly Hamilton's paper in the 'Transactions' of the Academy is accompanied by another from Lloyd describing the beautiful arrangements by which he had succeeded in verifying this remarkable phenomenon in both its varieties.

This striking instance of scientific prediction naturally made a great sensation at the time, appealing, as it did, to a much larger public than the few select mathematicians who were capable of mastering the elaborate treatise on 'Systems of Rays.'

The experimental skill that was required to obtain these results may be realised from the circumstance that as I have been told the French physicists found themselves unable to repeat the experiment till Lloyd himself went over to Paris with his instruments and showed them the way.

Hamilton was so well satisfied with the success of his new method in dealing with the problems presented by the propagation of Light that full of enthusiasm he proceeded to apply a generalised form of the same method in the investigations of the motion of any material system, and a paper of his was read before the Royal Society in 1834 with the following title: 'On a general method in Dynamics by which the Study of the Motions of all free systems of attracting or repelling points is reduced to the Search and Differentiation of one Central Relation, or Characteristic Function.'

To show the importance attached by the most competent judges to Hamilton's work in this field of Theoretical Dynamics, we cannot do better than quote the words of his great German contemporary Jacobi, who afterwards himself added to the new theory such valuable developments.

Jacobi writes as follows:—'If a free system of material points is acted on by no other forces than such as arise from their mutual attraction or repulsion, the differential equations of their motion can be represented in a simple manner by means of the partial differential coefficients of a single function of the coordinates. Lagrange, who first made this important observation, at the same time showed that this form of the differential equations possesses great importance for Analytical Mechanics. The marked attention, therefore, of mathematicians could not fail to be aroused when Herr Hamilton, Professor of Astronomy in Dublin, indicated in the "Philosophical Transactions" that in the Mechanical problem referred to all the integral equations of motion might be represented in just as simple a manner by means of the Partial Differential Coefficients of a single function. This is undoubtedly the most considerable extension which Analytical Mechanics has received since Lagrange.'

It will be of interest to the Section to recall the fact that Hamilton and Jacobi met each other for the first and I fancy the only time at a Meeting of this Association, held in Manchester in 1842, at which meeting Jacobi, addressing this Section, called Hamilton 'le Lagrange de votre pays.'

The last third of Hamilton's life was mainly devoted to the development of his Quarternion Calculus. As early as 1828 his Class Fellow, J. T. Graves, who had been working at the theory of the use of imaginary quantities in Mathematics, wrote an essay on Imaginary Logarithms which he wished to get printed by the Royal Society. There appears to have been some hesitation amongst the leading mathematicians in the Society, notably, Herschel and Peacock, about publishing Graves' paper, as they felt dubious about the accuracy of his reasoning. Hamilton heard of this and wrote earnestly to Herschel defending his friend's conclusions, and it seems as if his generous desire to help his friend first set his own mind working in this direction.

For years his busy brain in the midst of all his other work kept pondering over this question of the interpretation of the imaginary, and he has left us in his 'Lectures on Quaternions' an elaborate account of the many systems he devised.

It was only in 1843, fifteen years later, that he first invented the celebrated laws of combination of the quadrantal versors of the Quaternion Calculus. Argand, Cauchy, and others had proposed for space of two dimensions the theory now known as that of the Complex Variable. For them $x+iy$ meant the vector to the point xy, and the product of two vectors meant a new vector of the same form, the only law required being that i operating upon i was always equivalent to -1.

Many attempts had been made to form on similar lines a Calculus which should apply to space of three dimensions; but so far all such attempts had proved unsuccessful, the laws by which the new symbols acted upon one another leading to results hopelessly involved. It was here that Hamilton's wonderful faculty of scientific imagination came into play. He proposed that a vector should be denoted by $ix+jy+kz$. As in the theory of the complex variable in two dimensions the result of any number of successive operations always preserved the fundamental type $a+ib$, so it was desirable that the result of the successive operations of his vectors should issue in an equally simple fundamental type. This end he found he could attain if he discarded the commutative principle which hitherto had barred his own progress and that of others, yet preserving the distributive and associative principles, and finally one happy evening he arrived at the beautifully simple laws by which the symbols of this Calculus act upon each other; that not only $i^2=j^2=k^2=-1$, but also that $ij=-ji=k, jk=-kj=i, ki=-ik=j$.

Though it was thus—as the product, that is, of two vectors—that the Quaternion first presented itself to Hamilton, he of course saw that it immediately followed that it might be regarded as the ratio of two vectors, in other words the operation which turned one vector into another. In fact in the more synthetic exposition which is contained in 'The Elements' he makes this latter the starting definition of the Quaternion.

It is noteworthy that this the more complete and systematic presentation of the subject by its illustrious author may be said to owe its origin to the keen interest my predecessor, Professor Tait, took in the new Calculus, of which, as you know, he ever afterwards remained the most ardent champion. This interest led him to seek from Dr. Andrews an introduction to Hamilton, and the encouragement came to Hamilton at an opportune moment, for he wrote:—

'It was useful to me to have my attention recalled to the whole subject of the Quaternions, which I had been almost trying to forget, partly under the impression that nobody cared or would soon care about them. The result seems likely to be that I shall go on to write some such "Manual," but necessarily a very short one.'

The 'Manual' thus foreshadowed became the voluminous treatise 'The Elements of Quaternions.'

Those interested in the future of Quaternions will have welcomed the new edition of this work brought out by the present occupant of Hamilton's Chair, Professor Charles Joly, who has himself also added some remarkable developments to one branch of the subject, the Theory of the Linear Vector Equation.

Hamilton's Quaternions may be viewed in two lights, as a development of the logic and philosophy of symbols in their relation to space of three dimensions and also as an instrument of research in Geometry and Physics. In the former aspect the Quaternions will ever remain a splendid monument of the imagination and genius of its inventor. In the latter point of view, that is, when we come to regard it as a working calculus, it would be premature as yet to fix the place it will ultimately occupy.

A few years after Hamilton had entered upon his scientific career James MacCullagh won his Fellowship in Trinity College. After an interval of three years he was appointed Professor of Mathematics, and eight years later succeeded Dr. Lloyd in the Chair of Natural Philosophy. It would be difficult to overestimate the stimulating effect of MacCullagh's lectures as Professor upon the Mathematical School. Many of those whose names stand out afterwards—such men as Jellett, Michael and William Roberts, Haughton, Townsend, and our present honoured Provost—were MacCullagh's pupils. To the present day the tradition still lingers in Trinity College of the impression MacCullagh made upon the minds of those with whom he came in contact.

When, passing from his influence as a teacher, we come to examine his own original work we find that this naturally divides itself into two departments, the first embracing Geometry and that part of the field of Mathematical Physics which most resembles Geometry, that in which the fundamental principles are entirely agreed upon; the second his work in Physical Optics, where he has to imagine new principles which, mathematically developed, should correlate the empirical laws hitherto obtained and be capable of verification by experiment.

Of the first class we have his studies in 'Surfaces of the Second Degree.' The most striking result he here obtained was the discovery of the modular generation of the quadric, thus extending to surfaces the focus-and-directrix property of the conic in plano. We are also indebted to him for some very elegant theorems in the theory of confocal quadrics, a subject to which he devoted much attention. He likewise gave a course of lectures containing a masterly discussion and geometrical presentment of the motion of a rigid body round a fixed point not acted on by external forces.

At the very outset of his career as an original author he seems to have been attracted by the theory of Light. To understand the ardour with which MacCullagh and his contemporaries devoted their mathematical powers to Physical Optics, we must endeavour to recall the circumstances of the time. The celebrated memoirs of Fresnel had recently appeared. In these he had proved, following Young, that the ethereal vibrations which constitute Light must be in the plane of the wave-front; that a beam of polarised light was simply a system of parallel waves in which these transverse vibrations were all in one direction. He had applied the theory of the ellipsoid to prove that there were three directions in a crystal in which the restitution-force coincided with the direction of the vibrations; that in the plane of every wave there are two directions along which, if a particle vibrate, the component of the restitution-force resolved in the plane of the wave will be along the direction of displacement. He had also from these principles deduced the equation of his famous wave-surface.

How much the work of Fresnel filled the imagination of scientific men in those days may be seen from the enthusiastic language which the sober-minded Dr. Humphrey Lloyd allows himself to use about him in his valuable report on Physical Optics, which he wrote for this Association in 1834.

In passing I would say that the name of Fresnel reminds us of the loss Science, and especially this Section, has sustained since we last met in the death of that illustrious French physicist who devoted his life with such ardour and success to the same field of research—Alfred Cornu. Those of us who had the privilege of being present will recall with a sad pleasure the beautiful address he gave us in Cambridge on the Wave Theory of Light on the occasion of Sir George Stokes' jubilee.

Fresnel in his analysis had assumed that when the molecules of the ether are disturbed by the passage of a wave the force of restitution acting upon a molecule depends upon that molecule's absolute displacement. Cauchy and Neumann and, in England, Green, improved on Fresnel's reasoning, making this force depend not on the absolute but on the relative displacement; all these physicists, however, worked on the lines of endeavouring to form an explanation of the propagation of the waves of Light, by treating them as the waves in an elastic medium, akin in its properties to a solid medium in which the stresses depend on the deformation of the elements.

MacCullagh agreed with these others in making the forces of restitution depend on the relative displacements as expressed through a certain function V, which represented the potential energy of the medium. In the further development of the theory he, however, diverges from them and adopts a line of his own. Struck by the significance of the fact, to which he seems to have been the first to direct attention, that the vector whose components are

$$\frac{1}{2}\left(\frac{dv}{dz}-\frac{dw}{dy}\right), \frac{1}{2}\left(\frac{dw}{dx}-\frac{du}{dz}\right), \frac{1}{2}\left(\frac{du}{dy}-\frac{dv}{dx}\right),$$

which we now, of course, know as the vector of molecular rotational displacement, was, so to speak, a physical vector, independent of the choice of our axes of coordinates, he was led to the idea of choosing for the form of V that of a homogeneous quadric in these three components. It must be admitted that the reasoning by which he attempts to prove the necessity of this assumption is eminently unsatisfactory, and that the assumption itself lay open to an apparently fatal objection urged later by Stokes, that of neglecting to secure the equilibrium of the element of the medium *quoad* moments.

Having, however, adopted this form of V, MacCullagh proceeds (making the assumption that while the elasticity of the medium varied the density was everywhere the same), by processes of remarkable elegance and simplicity, to develop the laws of wave propagation in a crystal, thus verifying the wave-surface of Fresnel, while at the same time he found himself able to satisfy completely the requirements at the limits. He could also point to experience, *e.g.*, the experiments of Brewster and Seebeck, as justifying the simple and beautiful laws which he had succeeded in obtaining.

Nevertheless the force of Stokes' objection was felt to be so strong that one who reviewed the subject, say thirty years ago, would have regarded MacCullagh's work in Optics as presenting indeed opportunities for beautiful mathematical developments, but lacking sound physical basis.

The publication, however, of the epoch-making treatise of Maxwell on Electricity and Magnetism entirely changed the aspect of the question, and in particular threw a new light on MacCullagh's assumption. FitzGerald, in 1879, pointed out that the Potential Energy, which in Maxwell's theory was equivalent to the electro-static energy, really was a quadratic function of three variables, which answered to the components of MacCullagh's molecular rotation, and accordingly led to the same differential equations of the motion as MacCullagh had deduced.

Subsequently Larmor, in his remarkable investigation of the Dynamical Theory of the Electric and Luminiferous Ether, deliberately reconsiders MacCullagh's position, finds in fact in his equations the starting-point of his own theory. He points out the real significance of MacCullagh's function V; that it corresponds to a stress-strain system, but one of a very novel type; one in which the stresses depend entirely on the rotational displacements of the molecules, and are otherwise absolutely unaffected by the ordinary deformation-strains. He further shows that the difficulty under which MacCullagh's theory laboured, that it did not provide for the rotatory equilibrium of the element, could be removed if we allowed ourselves to assume the existence of a hidden torque acting on each element.

As I understand the advocates of this theory, they maintain that an important step has been made, even though in the present state of our knowledge we may not be able to account for the existence of this hidden torque. They point out, however, that such a torque is at least not inconceivable, whether its explanation be sought in concealed kinetic phenomena, as in Lord Kelvin's material gyrostatically constituted medium, or in quasi-magnetic forces supposed to reside in the ethereal elements.

Should this theory of a rotationally elastic ether obtain final acceptance, it will of course be a matter of congratulation to MacCullagh's countrymen to find that his labours, in this, perhaps the most important field of his researches, have not been thrown away; that they represent no mere play of elegant mathematical analysis, but a real step in the progress of physical science.

A few years after MacCullagh, two other well-known men, whose names for half a century were associated with the Mathematical School in Dublin, were elected Fellows—Andrew Searle Hart, afterwards Sir Andrew Hart, and Charles Graves, subsequently Bishop of Limerick. They won their Fellowships in two successive years, and both lived to an advanced age.

Hart had a great reputation as a geometer. His examination papers were specially noted for the number of original problems they contained. As specimens of his work we may instance the following. Extending Feuerbach's theorem for the nine-point circle, Hart showed that the circles which touch three given circles can be distributed into sets of four all touched by the same circle. He also showed that Poncelet's beautiful porism for coaxal circles in plano held for the surface of an ellipsoid, if we replace the rectilineal polygons by geodetic polygons and the coaxal circles by lines of curvature.

Graves became Professor of Mathematics on MacCullagh's resigning the Chair in 1843. He was largely influenced by the writings of Chasles, of whose two memoirs on Cones and Spherical Conics he published a translation. In this were incorporated valuable original additions of his own, amongst others the remarkable theorem that if two spherical ellipses are confocal the sum of the tangents drawn to the inner from any point of the outer exceeds the intercepted arc between the points of contact by a constant length, a theorem which of course includes the corresponding proposition for confocals in plano. Graves was one of the first to apply the method of the Separation of Symbols to Differential Equations, and gave an elegant demonstration by this method of Jacobi's celebrated test for distinguishing between maxima and minima in the Calculus of Variations.

On the death of MacCullagh it was determined to strengthen the Natural Philosophy department by the establishment of a second Professorship in that subject, and Jellett, one of the ablest of MacCullagh's pupils, was appointed to the new Chair.

His first published work was his 'Calculus of Variations,' which at the time it was written constituted the only systematic English treatise on the subject. It is marked by that peculiar acuteness and power of fastening on essential points, whether for criticism or exposition, which was the author's leading characteristic. Apart from the excellent account he gives of the researches of Continental mathematicians, I would notice especially his most interesting chapters on the conditions of integrability and many valuable geometrical theorems on surfaces hence resulting. In discussing his more properly original work we may arrange it in three divisions: 1st, his papers on Elasticity; 2nd, that on the properties of Inextensible Surfaces; 3rd, those on the application of polarised light to the new subject of Chemical Equilibrium.

In taking up the problem of an elastic medium and the propagation of waves in such medium, Jellett follows the example of MacCullagh, who had made this subject one of special interest to the Dublin school. In these memoirs he draws attention to a remarkable difference in the mode of regarding the molecular constitution of the medium, a difference corresponding to what is now known as the distinction between the Rari-constant and Multi-constant theories. We may, Jellett points out, regard the action between two molecules as only conditioned by the relative position of these molecules, or as dependent also on the position of the neighbouring molecules. The first is termed by Jellett the hypothesis of independent action, and this he shows to lie at the basis of Cauchy's theory, whereas the theory of Green, the English elastician, essentially involves the second hypothesis which Jellett calls 'modified action.' He established in the same papers the important theorem that if a Work function exists the three directions of vibration, corresponding to a plane-wave, are rectangular, and *vice versâ*.

In his memoir on Inextensible Surfaces various interesting questions are discussed. He proves that in the case of a synclastic surface if a closed curve on the surface be held fixed, the entire surface will be immovable; that on the other hand on an anticlastic surface it is possible to draw a curve which may be held fixed without involving the immovability of the surface, the conditions being that the curve will be that formed by the successive elements of the inflexional tangents. The mathematical theory of such curves had been already studied, but Jellett seems to have been the first to signalise their importance in the theory of deformation, and, on account of the property referred to, he proposed to call them Curves of Flexure. It is interesting to remark that Maxwell was attracted by the same subject of Inextensible Surfaces, and in one of his earliest papers confirms by an entirely different method several of Jellett's conclusions.

At the close of Jellett's paper a remarkable proposition is laid down, apparently for the first time, that a closed oval surface cannot be inextensibly deformed; in other words, that if such a surface be perfectly inextensible it is also perfectly rigid. I think we must admit that the proof of this striking theorem offered by Jellett is by no means satisfactory. Subsequent attempts by others to establish this proposition can hardly be said to be more successful. But the fact that it can be rigorously proved true for a sphere or more generally for any ellipsoid seems to indicate that we have here to do with a real and important theorem, but one which needs, as is so often the case, to have the limits of its application more clearly defined.

Many experimental physicists will know Jellett best by the beautiful and delicate instrument he invented, 'The Double-plane Analyser,' an instrument which he devised in order to secure the more exact determination of the rotation of the plane of polarisation than could be obtained by the polariscopes hitherto in use. Jellett was actuated here by the consideration that he saw in this phenomenon of the rotation of the plane of polarisation a means of attacking the interesting problem of chemical equilibrium. Chemical equilibrium he defines thus: 'Two or more substances may be said to be in chemical equilibrium, if they can be brought into chemical presence of each other (as in a solution) without the formation of any new compound or change in the amount of any of the former compounds which have thus been brought together.' In a mixed solution of sundry bases and acids where all the possible salts are soluble, what are the proportions in which the acids are distributed amongst the bases? Such was Jellett's question, and in answering it he arrives by a remarkable train of quasi-mathematical reasoning at certain laws governing this distribution, and proceeds to establish the truth of these laws by observation with his new polariscope.

He also discusses in the same papers two alternative theories which we can hold of chemical combination, the 'statical' and the 'dynamical,' and shows from the consideration of the number of equations which subsist that the 'dynamical theory' is alone admissible.

When the Association met in Belfast twenty-eight years ago Dr. Jellett occupied this Chair, and at the close of his Address, in which he took for his subject certain fresh applications of Mathematical Analysis to Physical Science, he touched upon these very researches in which he was at the time engaged.

All old Trinity men would think this enumeration incomplete if it did not refer to the wonderfully active animating presence of Samuel Haughton. He also directed his energies in the first instance to the subject of Elasticity, on which he wrote several important memoirs, endeavouring to formulate a system of laws by which he might be able to explain the propagation of Light. But apparently discouraged by the extreme difficulty of the problem his versatile brain turned soon to quite other branches of science—to Physical Geology, then to Physiology and Medical Science, and in fact in his later work he passes out of the cognisance of Section A.

Of the pure mathematicians trained under MacCullagh two of the most eminent were the twin brothers Michael and William Roberts. Strikingly alike in their personal appearance they were in my student days two of the best known figures in the Courts of Trinity.

In his geometrical work Michael Roberts pursued the fruitful lines of research started by Chasles and followed up by MacCullagh in the study of quadric surfaces, and it fell to his lot to discover some most remarkable theorems on the relations of the geodetics on the surface to the lines of curvature; theorems indeed to which the author would have been justified in applying words which Gauss used of a great theorem of his own:

'Theoremata quæ ni fallimur ad elegantissima referenda esse videntur.'

Joachimsthal had shown that the first integral of the equation of the geodetics on an ellipsoid could be thrown into the well-known form $PD = \text{constant}$. Michael Roberts now showed that the geodetics, which issue in all directions from an umbilic, pass through the opposite umbilic where they meet again by paths of equal length; that the lines of curvature considered with respect to two interior umbilics possess properties closely analogous to those of the plane conic with respect to its foci; that if such umbilics A and B be joined by geodetics to any point P on a given line of curvature they make equal angles with such line, and consequently that as P moves along the line of curvature, either $PA + PB$ or $PA - PB$ remains constant, so that if the ends of a string be fastened at the two umbilics and a style move over the surface of the ellipsoid, keeping the string stretched, the style will describe a line of curvature. Another remarkable analogue he proved was the following: that as in a plane conic if a point P on the curve be joined to the foci A and B,

$$\tan \tfrac{1}{2}(PAB) \tan \tfrac{1}{2}(PBA) = \text{const.}$$
$$\text{or } \tan \tfrac{1}{2}(PAB)/\tan \tfrac{1}{2}(PBA) = \text{const.}$$

so precisely the same relation holds for a line of curvature on the quadric, replacing the foci by the umbilics and the right lines by geodetics.

Sir Andrew Hart made a valuable contribution to the subject by investigating the relation between the angles which an umbilicar geodetic makes with the principal plane when it leaves the umbilic and when it returns to it again after going the circuit of the surface. He proved that if ω and ω' be these angles, $\frac{\tan \frac{1}{2}\omega'}{\tan \frac{1}{2}\omega}$ can be expressed by means of complete elliptic integrals independent of ω. This is interesting, as it shows that such a geodetic is not a finite closed curve, but that it crosses itself over and over again at the umbilics, the successive values of $\tan \frac{1}{2}\omega$ forming a geometric series.

To Michael Roberts is also due much important work in the department of pure analysis—notably, in modern Algebra his method of deriving Covariants, and the investigation of their relations by means of their sources, and in the theory of Abelian integrals his construction (following the method of Jacobi) of a Trigonometry of the hyperelliptic functions.

His brother William Roberts is perhaps best known for some of the investigations he carried out by means of elliptic coordinates. For example, he applied them to Fresnel's wave-surface, and showed that the two sheets of the surface can be expressed in the simple forms

$$\lambda^2 + \nu^2 = a^2 + b^2 - c^2 \quad \text{and} \quad \lambda^2 + \mu^2 = a^2 + b^2 - c^2.$$

By following the same method he succeeded also in adding an interesting new triple system of orthogonal surfaces to those already known.

Richard Townsend was another of the Fellows of Trinity of MacCullagh's school. He was known to us in College in my day as the great expositor of the new geometry of Anharmonics and Involution. He wrote many valuable original papers, but it was as a lecturer he was most remarkable. I never met a teacher so enthusiastic nor one who seemed to enjoy teaching more thoroughly.

He inspired his pupils with much of his own ardour, and it is greatly owing to Townsend's influence that the old name Trinity had for the study of Geometry was so well kept up in his day.

He published in the latter part of his life an extensive treatise on Modern Geometry, which did good service in presenting the subject in the light of an organised system and not as a collection of isolated problems.

In this connection I must not omit to mention one of our most original Irish geometers of recent days, Dr. John Casey. Where Casey learnt his Mathematics is indeed a marvel. Up to middle life he was engaged in the engrossing labour of a schoolmaster in Kilkenny under the National Board of Education. It was not till he was nearly forty that by the advice of Townsend, to whom he used to send up some of his ingenious geometrical solutions, he moved up to Dublin and entered Trinity College. Of his original papers his best known are those on Bicircular Quartics and Cyclides.

In elementary Geometry we owe to him a very elegant extension of Ptolemy's famous theorem that for four points, A B C D, on a circle AC . BD = AB . CD + AD . BC. Casey shows that the same equation is true if we replace the four points by four circles touching a common circle and the lines joining the points by the common tangents to the circles. He acquired so high a repute both as a teacher and as a writer that he was offered and accepted the post of Professor of Mathematics in the Catholic University

It is not yet two years since George FitzGerald was taken from us. The many loving tributes to his memory which appeared in the scientific journals after his death reveal to us how deep and widespread his loss was felt to be, but it is in Ireland this loss is most serious. As long as he lived and worked, our country could claim to own one of the foremost members of that select band who are endeavouring to wrest from Nature her inmost secrets.

You know how sedulous an attendant he was of the Meetings of this Section, and Trinity College never sent you a representative of whom she had more reason to be proud, for he has done more than any of her sons for many years to maintain the reputation of her scientific school. This he has brought about, not by his writings only, able and original as these were, but also by the encouragement and stimulus he gave the younger men he gathered round him, and the self-forgetful readiness with which he gave all the help he could to those who in any measure shared his own genuine love for science.

You will all rejoice that we are now in possession of a volume containing a complete collection of FitzGerald's scientific papers. I am sure he himself could not have wished for a better chronicler of his life and labour than his intimate friend Dr. Larmor, more especially as Dr. Larmor's own far-reaching speculations on the great mystery of the Ether qualify him in a very peculiar manner to appreciate the work of his fellow-physicist. The admirable analysis of that work in the opening pages of this volume renders any further account of it on my part completely unnecessary.

A few months before FitzGerald's death there passed away one of his most distinguished pupils, Thomas Preston. Though cut off so young he had already done much work, and of a quality which raised high expectations of his future. His treatises on Light and on Heat are to be noted, not merely for the excellent account they give of the recent additions to the subjects treated, but for the thoughtful and philosophic spirit in which the whole is presented. It was, however, his experimental researches which most excited attention, more particularly those on the action on Light of a strong electro-magnetic field and the fine experiments in which he extended beyond any observations hitherto made the analysis of the Zeeman effect.

Of two others I have yet to speak, and these were emphatically representatives of this city and of the College in whose Halls we are meeting to-day—Thomas Andrews and James Thomson. It would be difficult to describe adequately all the phases of so manifold an activity as that of Dr. Andrews. As one long associated with him as a colleague I would bear testimony to one side of his life-work—the potent influence he exercised in this College in its earlier years as a skilful pilot guiding the ship till it was well out of port. His high ideal of the function it should discharge in the education of the country and the practical zeal and ability which he ever brought to bear on the administration of our affairs contributed in no small measure to place the College in the assured position it occupies to-day.

On his great physical and chemical investigations it is happily the less necessary for me to touch, as they have been so fully brought before you by our President in his opening Address; and as regards the most important of these researches, those on the continuity of the Liquid and Gaseous states, no one assuredly could have more fitly expounded them than one who has himself pressed forward with such splended success in the paths which Andrews opened up.

I have always considered that Andrews, through the long course of these later researches, was most fortunate in having near at hand such a friend as James Thomson; not that he was a collaborator—for Andrews did all this work unaided—but that Thomson gave him throughout that best of all encouragement which consists in enlightened appreciation of the importance of the results he was obtaining and of their inner meaning and significance.

Of Thomson himself what shall I say? Of all the scientific men I have come across he perhaps most fulfilled the idea of a philosopher, his ever-working brain ever seeking out causes, ever pondering on the why and the wherefore of the unexplained.

One of his earliest investigations is perhaps the best known, that in which, basing his reasoning on Carnot's principle, he demonstrates the effect of pressure in lowering the freezing-point of water, and in which he gave at the same time a numerical estimate of this effect.

This discovery was of great practical import, for, small as the effect was, it enabled him to explain fully the rationale of the plasticity of ice.

Forbes had already shown that the motion of glaciers depended upon a plastic or viscous quality in the ice. It remained for Thomson, by the aid of his newly discovered principle, to go a step further and account for this plasticity.

It is interesting to note that the questions which led to some of his most valuable investigations seem to have been started by the filial task he took upon himself of re-editing his father's educational text-books. It was, for example, the revision of a chapter in his father's Geography which I believe led him to examine more thoroughly into Hadley's theory of the Trade winds, and to make the following important addition to that theory. He showed that while in the tropical latitudes, say of our northern hemisphere, two currents would satisfy all the conditions, *i.e.*, the Trade wind blowing from N.E. to S.W. in the lower regions of the atmosphere, and the return current in the upper regions, on the other hand that in the temperate latitudes there must be three currents at different elevations; that the uppermost and the lowest of these have a movement towards the pole, but in the middle regions of the atmosphere between these there must be a large return current from the Pole, and that the prevailing motions of all three currents would be from west to east.

Thomson was particularly successful in his treatment of this and other questions of fluid motion. He was not familiar with the technique of the higher mathematics, and on this very account was not tempted, as so many mathematical experts are, to assume impossible conditions in order to bring the problems within reach of their algebraic analysis; but for all that his mind was eminently of a mathematical cast. He is never vague or loose in his reasoning, and he had a wonderfully tenacious grasp of physical principles. The result was that he has succeeded in finding out the key to some of the most curious phenomena in the motions of fluids.

I may give as a typical instance of his line of reasoning his beautiful explanation of the action of the water of a river flowing round a bend. He saw clearly that from true dynamical principles the flow of the water must be most rapid near the inner bank, and the question which presented itself to his mind was why then the inner bank was not worn away. The answer he showed to consist in the friction of the bed checking the velocity of the lowest stratum of the water. The effect of this he proves to be that an under-current is produced in this stratum across the bed of the river from the outer towards the inner bank, a current which does two things: it carries sand and detritus and deposits them on the inner bank; and, since the water in this current has to rise vertically to the surface when it reaches this bank, it thus protects it from the scour.

In a review of Thomson's work we should emphasise his constant endeavour, whether in Mathematics or Physics, to attain clear conceptions of fundamental principles. This showed itself in the various innovations in nomenclature he introduced. Many of the new words he coined, 'radian,' 'numeric,' 'torque,' 'interface,' 'clinure,' 'posure,' &c., are great helps both in thinking and teaching.

The same determination at any cost of hard thinking to arrive at clearness in regard to fundamental principles is strikingly evidenced by one of his later papers, that on the 'Law of Inertia and the Principle of Chronometry,' which is a most searching discussion of the true significance of Newton's first and second laws of motion.

I must now close this review. I shall be glad if I have succeeded, however imperfectly, in giving you some impression of our Irish schools of Mathematics and Physics, of the workers and of the sources from which they drew their inspiration. There surely never was a time when the problems presented to the mathematician by Physical Science were more interesting; never a time when Science for its onward progress stood more in need of those gifted ones who combine clearness of thought with imagination and hopeful courage. Let us hope that amongst these in this new century, others of our countrymen may be found not unworthy to have their names inscribed in the roll which contains those of Hamilton and MacCullagh, of Andrews and Thomson.

The following Papers were read:—

1. *On the Question as to the Accurate Conservation of Weight in Chemical Reactions. By* Lord RAYLEIGH, *F.R.S.*

2. *Motion of a Detached Thread of Liquid in a Capillary Tube.*
By Professor W. B. MORTON, *M.A., and* W. HAWTHORN.

3. *On the Vibrations of a Plucked String.*
By Professor W. B. MORTON, *M.A., and* T. B. VINYCOMB.

4. *On Continuous Motion produced by Vibrations.*
By Professor W. B. MORTON, *M.A., and* A. M. KINSKY.

5. *On the Prevention of a Deposit of Dew on the Lenses of a Projecting Lantern. By* Professor A. SCHUSTER, *F.R.S.*

6. *Further Experiments by the Thermal Method on the Variation of the Critical Velocity of Water with Temperature.* *By* HOWARD T. BARNES, *M.A.Sc., D.Sc.*

In a paper communicated by the author with Dr. E. G. Coker to the British Association at Glasgow it was shown from a series of experiments by a new thermal method on the upper limit of stream-line flow that this point, at which stream-line motion breaks down, apparently does not follow the temperature function of Poiseuille exactly. A second series of measurements by the same method for a different pipe has given identically the same result.

Realising how contrary to theory the result of this experimental investigation seems to be, it was decided both by Dr. Coker and the author to carry out separate determinations involving measurements of the *lower limit* of stream-line flow and the dependence of the same on the temperature. Since the theoretical equations apply to this lower limit, which is the point where the law of resistance changes and the true criterion is obtained, a rigid adherence to the law of Poiseuille necessarily follows.[1]

In place of starting with water free from initial disturbance, as in our previous experiments, and measuring the velocity at which stream-line motion breaks down, water in a disturbed state was allowed to flow through a pipe of sufficient length to allow of the dying out of the eddies for velocities less than the critical. By surrounding the end of the pipe with a water-jacket at a slightly different temperature from that of the water flowing through, and using the thermometer as before, it has been possible to determine: (*a*) the velocity at which all the eddies die out and stream-line motion is the stable flow; (*b*) the velocity at which the motion is entirely sinuous with no tendency to form stream-lines; and (*c*) the intermediate velocity where by the oscillation of the thread of the thermometer the formation of stream-lines and the breaking up into eddies were seen to follow in regular intervals. These experiments were made by the author partly to test the efficacy of the thermal method for determining the lower limit of stream-line flow with a view to extension to other liquids.

The result of this and the previous work may be summarised briefly as follows:—

1. An experimental verification of the law of Poiseuille for the temperature coefficient of the lower limit of stream-line flow.
2. That there is a small divergence from the law of Poiseuille in the case of the temperature coefficient of the upper limit of stream-line flow.
3. The reformation of stream-lines, shown both by the thermal method and colour-band tests, for velocities above that at which eddies first make their appearance.
4. The attainment of exceedingly high velocities of stream-line flow for certain sizes of pipes under steady conditions.

FRIDAY, SEPTEMBER 12.

DEPARTMENT II.—ASTRONOMY AND COSMICAL PHYSICS.

CHAIRMAN: Professor A. SCHUSTER, Ph.D., F.R.S.

The Chairman delivered the following Address:—

OUR proceedings to-day constitute an innovation and require a few words of explanation. When, a few years ago, some astronomers felt that our Association bestowed an insufficient share of attention on their subject, an easy remedy suggested itself in the formation of a special sub-section devoted to that subject. Such a sub-section was accordingly organised at Bradford and Glasgow, but for reasons which are perhaps not altogether to be regretted the experiment was only partially successful. In the meantime the work of Section A became heavier and heavier, and as it seemed necessary to find some way of relieving its meetings it was decided to hand over to the already established sub-section of Astronomy other subjects, such as meteorology, terrestrial magnetism, seismology, and, in fact, anything that the majority of physicists are only too glad to ignore.

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[1] Osborne Reynolds, *Phil. Trans.*, 1883 and 1895.

When the Council of the British Association asked me to act as President of such an enlarged sub-section I was very doubtful whether I ought to accept the honour. In the first place, I felt incompetent, owing to my almost complete ignorance of most branches of astronomy, and in the second place I do not approve of the formation of sub-sections dealing with important branches of physics. If I eventually consented, it was partly because I lacked the strength of mind to refuse an honour of this kind, but partly because I was glad to have an opportunity of raising the whole question of the organisation of our meetings. The ground for such a discussion has, however, to a great extent disappeared, because when the Organising Committee of Section A met in the spring there appeared amongst those present a sudden revival of interest in the subjects assigned to the sub-section, and it was decided that the main section should not meet at all to-day, so as to allow all members to help us in our discussions. The parent Section has, therefore, voluntarily submitted itself to absorption by its neglected offspring, which now has to show that cosmical physics obey the laws of terrestrial physics, and that good absorbers are also good radiators.

Gratifying as this reunion must be to us, it fails to realise one of the original objects for which we have been called into existence, because instead of lightening your work it has added to it by imposing upon you the burden of having to listen to a second Presidential Address. I will try to make this additional burden as light as possible by concentrating my general remarks into a few sentences, and then introducing the business of the Section by means of a contribution to its scientific work, which I otherwise would have made in the ordinary course of the meeting.

To make our meetings as fruitful as possible, we would make the fullest use of the opportunities afforded us of personal contact and interchange of ideas. This is not accomplished by dividing into separate camps as soon as we have come together, but rather by finding some common ground for our debates. We should not try to minister to the separate needs of the specialist in electricity, or in meteorology, or in astronomy, but should impress upon each of these specialists that he must bring before us the results of his investigations in so far as they bear on the more general questions in which we all are, or ought to be, interested. If it is necessary to lighten the work of the Section this should be done by excluding all papers which are of interest only to specialists, or by establishing sub-sections for such papers. Let us divide—if divide we must—according to the character of the contribution, rather than according to the subject it happens to deal with. The difficult and, perhaps, unpopular censorship which such a course would involve would probably be temporary only, as the character of the papers which are desired for the main Section would soon become known, and the increased attraction and usefulness of our discussions would, I am convinced, in a few years compensate for the initial trouble. We all require, occasionally, to be reminded that the detail work which is necessary, and on which most of us are engaged, is only of importance or interest if it helps us forward towards the solution of the great problems of nature.

Addressing myself more particularly to astronomers, I should like to say that we shall always welcome them as members of Section A, and that the benefit we shall derive from their contributions will be great in proportion as they consider themselves to be citizens of the general empire of that Section, rather than inhabitants of an independently governed state.

There is a minor reform, or perhaps I ought to call it a protest, against one of the traditions of the Association which I feel called upon to urge on you. Discussion is our principal aim, and we are always trying to find suitable subjects for discussion; yet we are prevented by rule or custom from discussing the Presidential

Address and the reports of committees. Those who framed such a rule must have had some unfortunate idea that the dignity of the Chair might be endangered if some criticism happened to be expressed in the discussion of the chairman's address, or that the value of the report of a committee might be endangered by some adverse comment coming from outside. But it seems to me that a scientific society or association, and especially one framed on a democratic constitution, ought not to take such a narrow and unscientific view. I can remember several Presidential Addresses which might, and probably would, have given rise to most instructive debates had the rule not existed.

Reports of committees if not suitable for discussion should not be read at all; but if read they should be open to discussion.

I hope that to-day you will not feel yourselves bound by ancient custom, but in order that, at any rate, the more scientific portion of my contribution to our proceedings, should not be stained by the suspicion of immaculate conception, I will now ask the duly constituted President of our Section to take his proper place.

The question I wish to bring to your notice to-day is an old one: if two events happen simultaneously, or one follows the other at a short interval of time, does this give us any reason to suppose that these two events are connected with each other, both being due to the same cause, or one being the cause of the other? Everyone admits that the simple concurrence of events proves nothing, but if the same combination recurs sufficiently often we may reasonably conclude that there is a real connection. The question to be decided in each case is what is 'sufficient' and what is 'reasonable.' Here we must draw a distinction between experiment and observation. We often think it sufficient to repeat an experiment three or four times to establish a certain fact; but with meteorological observations the case is different, and it would, *e.g.*, prove very little if on four successive full moons the rainfall had been exceptionally high or exceptionally low. The cause of the difference lies in the fact that in an experiment we can control to a great extent all the circumstances on which the result depends, and we are generally right in assuming that an experiment which gives a certain result on three successive days will do so always. But even this sometimes depends on the fact that the apparatus is not disturbed, and the housemaid has not come in to dust the room. Here lies the difference. What is possible in a laboratory, though perhaps difficult, is not possible in the upper regions of the atmosphere where some unseen hand has made a clean sweep of some important condition.

When we cannot control accessory circumstances we must eliminate them by properly combining the observations and increasing their number. The advantage does not lie altogether on the side of experiment, because the very identity of condition under which the experiment is performed gives rise to systematic errors, which Nature eliminates for us in the observational sciences. In the latter also the great variety in the combinations which offer themselves allow us to apply the calculus of probability, so that in any conclusion we draw we can form an idea of the chance that we are wrong. Astronomers are in the habit of giving the value of the 'probable error' in the publication of their observations. Meteorologists have not adopted this custom, and yet their science lends itself more readily than any other to the evaluation of the deviations from the mean result on which the determination of the probable error depends. We look forward to the time when weather forecasts will be accompanied by a statement of the odds that the prediction will be fulfilled.

The calculation of the probability that any relationship we may trace in different phenomena indicates a real connection seems to me to be vital to the true progress of meteorology, and although I have on previous occasions[1] already drawn attention to this matter I should like once more to lay stress on it.

The particular case I wish to discuss, though the methods are not restricted to this case, is that in which one of the two series of events between which relationship is to be established has a definite period, and it is desired to investigate the evidence of an equal period in the other series.

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[1] *Cambridge Phil. Trans.*, vol. xviii. p. 107.

Connections between the moon and earthquakes, or between sunspots and rainfall if proved to exist, would form examples of such relationship. The question to be decided in these cases would be: Is there a lunar period of earthquakes, or an eleven years' sunspot period of rainfall?

Everyone familiar with Fourier's analysis knows that there is a lunar or sunspot, or any other period in any set of events from volcanic eruptions down to the birth-rate of mice; what we want to find out is, whether the periodicity indicates a real connection or not. Let us put the problem into its simplest form. Take n balls, and by some mechanism allow them to drop so that each falls into one of m compartments. If finally they are equally distributed each compartment would hold n/m balls. If different compartments contain a different number of balls, we may wish to find out whether the observed inequality is sufficient to indicate any preference for one compartment, or how far it is compatible with equality of chance for each. If we were able to repeat the experiment as often as we liked, we should have no difficulty in deciding between the two cases, because in the long run the average number received by each compartment would indicate more and more closely the extent of bias which the dropping mechanism might possess. But we are supposed to be confined to a single trial, and draw our conclusions as far as we can from it.

It would be easy to calculate the probability that the number of balls in any one compartment should exceed a given number; but in order to make this investigation applicable to the general problem of periodicities we must proceed in a different manner. If the compartments are numbered—it does not matter in which order—and a curve be drawn in the usual manner representing the connection between the compartments and the number of balls in each, we may, by Fourier's analysis, express the result by means of periodic functions. The amplitude of each period can be shown *on the average* to be $\frac{1}{m}\sqrt{\pi n}$. It is often more convenient to take the square of the amplitude—call it the intensity—as a test, and we may then say that the 'expectancy' of the intensity is $4n/m^2$. The probability that the intensity of any period should be k times its average or expectancy is e^{-k}. We may apply this result to test the reality of a number of coincidences in periods which have been suspected. A lunar effect on earthquakes is in itself not improbable, as we may imagine the final catastrophe to be started by some tidal deformation of the earth's crust. The occurrence of over 7,000 earthquakes in Japan has been very carefully tabulated by Prof. Knott according to lunar hours, who found the Fourier coefficient for the lunar day and its three first sub-multiples to be 10·3, 17·9, 10.9, 3·97; the expectancy on the hypothesis of chance distribution for these coefficients I find to be 19·3, 15·7, 10·6, 5·02. The comparison of their numbers disproves the supposed connection; on the other hand, the investigations of Mr. Davison on solar influence have led to a result much in favour of such influence, the amplitude found being in one series of observations equal to five times, and in the other to fifteen times the expectancy. The probability that so large an amplitude is due to accident in the first case is one in 300 millions, and in the second the probability of chance coincidence would be represented by a fraction, which would contain a number of over seventy in the denominator. We may therefore take it to be established that the frequency of earthquakes depends on the time of year, being greater in winter than in summer. With not quite the same amount of certainty, but still with considerable probability, it has also been shown that earthquake shocks show a preference for the hours between 9 A.M. and noon.

A great advantage of the scientific treatment of periodical occurrences lies in the fact that we may determine *à priori* how many events it is necessary to take into account in order to prove an effect of given magnitude. Let us agree, for instance, that we are satisfied with a probability of a million to one as giving us reasonable security against a chance coincidence. Let there be a periodic effect of such a nature that the ratio of the occurrence at the time of maximum to that at the time of minimum shall on the average be as $1+\lambda$ to $1-\lambda$, then the number of observations to establish such an effect is given by the equation $n=200/\lambda^2$.

If there are 2 per cent. more occurrences at the time of maximum than at the time of minimum $\lambda = 0{\cdot}01$, and n is equal to 2,000,000, showing the large number of events required to prove an effect which is small. If the effect is 5 per cent. the number of events required to establish it is 80,000.

To further illustrate these results, I take, as a second example, a suggested connection between the occurrence of thunderstorms and the relative position of sun and moon. Among the various statistical investigations which have been made on this point, that of Mr. McDowall lends itself most easily to treatment by the theory of probability. One hundred and eighty-two thunderstorms observed at Greenwich during a period of fourteen years have been plotted by Mr. McDowall as distributed through the different phases of the moon, and seem to show a striking connection. I have calculated the principal Fourier coefficient from the data supplied, and find that it indicates a lunar periodicity giving for the ratio of the number of thunderstorms near new moon to that near full moon the fraction 8·17 to 4·83.

This apparently indicates a very strong effect, but the inequality is only twice as great as that which we should expect if thunderstorms were distributed at random over the month, and the probability of a true connection is only about twenty to one. No decisive conclusions can be founded on this, the number of thunderstorms taken into account being far too small. We might dismiss as equally inconclusive most of the other researches published on the subject were it not for a remarkable agreement among them, that a larger number of storms occur near new moon than near full moon.

I have put together in the following table the results of all investigations that are known to me. Following the example of Koeppen, I have placed in parallel columns the number of thunderstorms which have occurred during the fortnight, including new moon, and the first quarter and the fortnight, including the other two phases.

Place of Observation and Author	Time of Observations	Percentage of Thunderstorms during the fortnight including	
		New Moon and First Quarter	New Moon and Last Quarter
Karlsruhe (Eisenlohr)	1801–31	50·8	49·2
Gotha (Luedicke)	1867–75	72·5	27·5
Vigevano (Schiaparelli) . . .	1827–64	46	54
Germany (Koeppen) . . .	1879–83	56	44
Glatz (Richter)	1877–84	62	38
United States (Hazen) . . .	1884	56·5	43·5
Prague (Grüss)	1840–59	51	49
„ „	1860–79	52·5	47·5
Göttingen (Meyer) . . .	1857–80	54	46
Kremsmunster (Wagner) . .	1862–87	53·8	46·2
Aix-la-Chapelle (Polis) . . .	1833–92	54·4	45·6
Sweden (Eckholm) . . .	1880–95	53·8	46·2
Batavia (v. d. Stock) . . .	1887–95	51·9	48·1
Greenwich (McDowall) . . .	1888–91	54	46
Average . . .		54·9	45·1

It will be seen that out of fourteen comparisons thirteen show higher numbers in the first column, there being also, except in two cases, a general agreement on the magnitude of the effect. Two of the stations given in the table, Göttingen and Gotha, are perhaps geographically too near together to be treated as independent stations, and we may therefore say that there are thirteen cases of agreement, against which there is only one published investigation (Schiaparelli) in which the maximum effect is near full moon.

The probability that out of thirteen cases in which there are two alternatives, selected at random, twelve should agree and one disagree, is one in 1,200. When the details of the investigations summarised in the above table are examined, considerable differences are found, the maximum taking place sometimes before new moon and sometimes a week later. There is, however, apparently sufficient *primâ facie* evidence to render an exhaustive investigation desirable. The most remarkable of all coincidences between thunderstorms and the position of the moon remains to be quoted. A. Richter has arranged the thunderstorms observed at Glatz, in Silesia, according to lunar hours, and finds that in each of seven successive years the maximum takes place within the few hours beginning with upper culmination. If this coincidence is a freak of chance, the probability of its recurrence is only one in 300,000. The seven years which were subjected to calculation ended in 1884. What has happened since? Eighteen years have now elapsed, and a further discussion with increased material would have definitely settled the question, but nothing has been done, or, at any rate, published. To me it seems quite unintelligible how a matter of this kind can be left in this unsatisfactory state. Meteorological observations have been allowed to accumulate for years—one might be tempted to say for centuries—yet when a question of extraordinary interest arises we are obliged to remain satisfied with partial discussion of insufficient data.

The cases I have so far discussed were confined to periodical recurrences of single detached and independent events, the condition under which the mathematical results hold true being that every event is entirely independent of every other one. But many phenomena which it is desirable to examine for periodic regularities are not of this nature. The barometric pressure, for instance, varies from day to day in such a manner that the deviations from the mean on successive days are not independent. If the barometer on any particular day stands half an inch above its average, it is much more likely that on the following day it should deviate from the mean by the same amount in the same direction than that it should stand half an inch below its mean value. This renders it necessary to modify the method of reduction, but the theory of probability is still capable of supplying a safe and certain test of the reality of any supposed periodic influence. I can only briefly indicate the mathematical theorem on which the test is founded. The calculation of Fourier's coefficients depends on the calculation of a certain time integral. This time integral will for truly homogeneous periodicities oscillate about a mean value, which increases proportionately to the interval, while for variations showing no preference for any given period the increase is only proportional to the square root of the time.

Investigations of periodicities are much facilitated by a certain preliminary treatment of the observations suggested by an optical analogy. The curve, which marks the changes of such variables as the barometric pressure, presents characteristics similar to those marking the curve of disturbance along a ray of white light. The exact outline of the luminous disturbance is unknown to us, but we obtain valuable information from its prismatic analysis, which enables us to draw curves connecting the period and intensity of vibration. For luminous solids we thus get a curve of zero intensity for infinitely short or infinitely long radiations, but having a maximum for a period depending on temperature. Gases, which show preference for more or less homogeneous vibrations, will give a serrated outline of the intensity curve.

I believe meteorologists would find it useful to draw similar curves connecting intensity and period for all variations which vary round a mean value, such as barometric, thermometric, or magnetic variations. These curves will, I believe, in all cases add much to our knowledge; but they are absolutely essential if systematic searches are to be made for homogeneous periods. The absence of any knowledge of the intensity of periodic variation renders it, *e.g.*, impossible to judge of the reality of the lunar effect which Eckholm and Arrhenius believe to have traced in the variations of electric potential on the surface of the earth. The problem of separating any homogeneous variation, such as might be due to lunar or sunspot effects, is identical with the problem of separating the bright lines of the chromosphere from the continuous overlapping spectrum of the sun. This separation is accomplished by applying spectroscopes of great resolving powers. In the Fourier analysis resolving power corresponds to the interval of time which is taken into account; hence, to discover periodicities of small amplitude we must extend the time interval of the observations.

I believe that the curve which connects the intensity with the period will play an important rôle in meteorology. It is a curve which ought to have a name, and for want of a better one I have suggested that of 'periodograph.' To take once more barometric variations as an example, it is easy to see that just as in the case of white light the periodograph would be zero for very short, and probably also for very long periods. There must be some period for which intensity of variation is a maximum. Where is that maximum? And does it vary according to locality? The answer to these questions might give us valuable information on the difference of climate. Once the periodograph has been obtained, the question of testing the reality of any special periodicity is an extremely simple one. If h be the height of the periodograph, the probability that during the time interval chosen the square of the Fourier coefficient should exceed kh is e^{-k}. If we wish this quantity to be less than a million k must be about eleven; so that in order to be reasonably certain that any periodicity indicates the existence of a truly homogeneous variation the square of the Fourier coefficient found should not be less than eleven times the corresponding ordinate of a periodograph.

I have calculated in detail the periodograph of the changes of magnetic declination at Greenwich, taking as a basis the observations published for the twenty-five years, 1871–95. It was not perhaps a very good example to choose, on account of the complications introduced by the secular variation, but my object was to test the very persistent assertions that have been made as to the reality of periodic changes of 26 days or thereabouts. The first suggestion of such a period came from Hornstein, of Prague, who ascribed the cause of the period to the time of revolution of the sun round its axis. He only discussed the records for one year's observations, but the evidence he offered was sufficient to impress Clerk Maxwell with its genuineness. Since Hornstein's first attempts a great many rough and some very elaborate efforts have been made by himself and others to prove a similar period in various meteorological variations. The period found by different computors differed, but there is a good deal of latitude allowed if the rotation of the sun really has an effect on terrestrial phenomena, because the angular velocity of the visible solar surface varies with the latitude. Hornstein himself and some of his followers deduced a period not differing much from 26 days, while Professor Frank Bigelow, using a large quantity of material, finds 26·68 days, and Eckholm and Arrhenius return to 26 days, or, as they put it more accurately, to 25·929 days. The two latter investigators do not, however, adopt the idea that this periodicity is due to the rotation of the sun. None of these periods can stand the test of accurate investigation.

As the result of my calculations I can definitely state that the magnetic declination at Greenwich shows no period between 25·5 and 27·5 days having an amplitude as great as 6″. The influence of solar rotation on magnetic variation may therefore be considered to be definitely disproved.

The intensity of the periodograph increases rapidly with the period, and minute variations are therefore more easily detected in short than in longer periods. Six seconds of arc forms about the limit of amplitude which can be detected in twenty-five years of observation when the period is about 26 days, and from what has been said above the amplitude which can be detected will be seen to vary inversely with the square root of the time interval. For periods of about 14 days an amplitude of 3″ is still distinguishable with the material I have used, and such an amplitude is actually found for a period which has half the synodic month as its time. The chance that this apparent variation is due to an accidental coincidence is one in 2,000, and I cannot therefore assert its definite existence beyond all possibility of cavil. But it is surely significant that of all the periods possible between 12·3 and 13·7 days that gives the highest amplitude which coincides with half the synodic revolution of the moon. That it is at all possible to detect variations of 3″ in the observations which are taken to 6″, with a probability of error of only one in 2,000, is, I think, a proof of the value of the method and the carefulness of the observations. The periodograph has another valuable use. It not only gives us the time necessary to establish true periodicities of given amplitude, but it also gives us an outside limit of the time beyond which an accumulation of material is of no further advantage. That limit is reached when the time is sufficient to discover the smallest amplitude which the instrument, owing to its imperfections, will allow us to detect.

I am only concerned to-day with a purely statistical inquiry, and not with the explanation of any suggested relationship. To prevent misunderstandings, however, I may state that I consider the possibility of a direct magnetic or electric action of the moon excluded. As regards the latter the diurnal variations of electric potential would be so strongly affected by a lunar electrification sufficiently strong to influence the outbreak of thunderstorms that it could not have escaped discovery. We must not, however, be dogmatic in asserting the impossibility of indirect action. The unexpected discovery of radio-activity has opened out an entirely new field, and we cannot dismiss without renewed careful inquiry the evidence of lunar action which I have given. Its reality can be decided by observation only. No, not by observation only, but by observation supplemented by intelligent discussion; and this brings me to my concluding appeal, which I wish to urge upon you with all the legitimate weight of strong conviction and all the illegitimate influence of presidential infallibility.

The subjects with which our sub-section is concerned deal with facts which are revealed to us by observation more frequently than by experiment. There is, in consequence, a very real danger that the importance of observation misleads us into mistaking the means for the end, as if observation alone could add anything to our knowledge. Observation is like the food supplied to the brain, and knowledge only comes through the digestion of the food. An observation made for its own sake, and not for some definite scientific object, is a useless observation. Science is not a museum for the storage of disconnected facts and the amusement of the collecting enthusiast. I dislike the name 'observatory' for the astronomical workshop, for the same reason that I should dislike my body to be called a food receptacle. Your observing dome would be useless without your computing room and your study. What you want is an astronomical laboratory, a meteorological or magnetic laboratory, attaching to the word 'laboratory' its true meaning, which is a workshop in which eyes and hands and brain unite in producing a combined result.

The problems which confront the astronomer being more definite than those of meteorology, astronomy has grown under the stimulus of a healthy tradition. Hence it is generally recognised, at any rate in the principal observatories, that the advance of knowledge is the chief function of the observer. Nevertheless the President of the Astronomical Department of Section A last year (Professor H. H. Turner) has found it necessary, in his admirable Address, to warn against the danger there is that the astronomer should allow himself to be swallowed up in routine work and mere drudgery.

The descent is easy: you begin by being a scientific man, you become an observer, then a machine, and finally—if all goes well—you design a new eyepiece.

If such a danger exists in astronomy, what shall we say about meteorology; That science is bred on routine, and drudgery is often its highest ambition. The heavens may fall in, but the wet bulb must be read. Observations are essential, but though you may never be able to observe enough, I think you can observe too much. I do not forget the advances which meteorology has made in recent years, but if you look at these advances I think you will find that most of them do not depend on the accumulation of a vast quantity of material. The progress in some cases has come through theory, as in the applications of thermodynamics or through special experiments, as by kite and balloon observations, and when it has come through the ordinary channels of observation only a comparatively short period of time has been utilised. It would not be a great exaggeration to say that meteorology has advanced in spite of the observations and not because of them.

What can we do to mend matters? If we wish to prepare the way for the gradual substitution of a better system, we should have someone responsible for the continuation of the present one. For this purpose it should be recognised that the head of the Meteorological Office is something more than a secretary to a board of directors; also that he is appointed to conduct meteorological research and not to sign weather forecasts. The endowment of meteorology should mean a good deal more than the endowment of the telegraph office which transmits the observations. Terrestrial magnetism and atmospheric electricity are at present looked after by institutions already overworked in other directions, and should be handed over to an enlarged department of meteorology.

Seismology in this country at present depends on the private enterprise and enthusiasm of a single man, and as long as Professor Milne is willing to continue his work we cannot do better than leave it with him, but some permanent provision will ultimately have to be made.

An improved organisation such as I have sketched out would do good, but could only very slowly overcome the accumulated inertia of ages. I should prefer a more radical treatment. Organisation is good, but sometimes disorganisation is better.

Most earnestly do I believe that the subjects of meteorology and terrestrial magnetism, and possibly also of atmospheric electricity, could be most quickly advanced at the present moment if all observations were stopped for five years, and all the energy of every observer and computor was concentrated on the discussion of the results already obtained and the preparation of an improved scheme of observation for the future. When we have made up our minds what to do with the observations; when we have actually done it; when we know where our present instruments require refining or supplementing; and especially when we have found out whether we have not spent much time and trouble on unnecessary detail, then the time will have arrived for us to draw up an economical, sufficient, and efficient scheme of observations. At present we are disinclined to discontinue observations, though recognised as useless, for fear of causing a break. We make ourselves slaves to so-called 'continuity,' which is important, but may be, and I believe is being, too dearly purchased.

There are no doubt some, though probably not very many, observations which it is necessary to carry on continuously over long periods of time. But at present we are groping in the dark, and go on observing everything, and always in the hope that at some time the observations may prove useful. Our whole point of view in this respect wants altering. We should fix on our problem first and then provide the observations which are necessary for the solution of the problem. If for some definite purpose it is advisable to establish special observatories, let us not be afraid to do so, but especially let us not be afraid to discontinue the observatories, when the purpose for which they have been established has been served. Let us restrict, in the first instance, the secular observations to the smallest number, and concentrate our attention, for short periods of time, on some special question. Let us have, for instance, two or three years of thunderstorm observations, all countries joining in concentrating their energies to the elucidation of all the various features of their phenomena. When that is accomplished it will probably be found that thunderstorms may be left to shift for themselves for a while, and attention directed to some other matter. The whole question of lunar influence on meteorological phenomena might be settled in a comparatively short space of time if the civilised countries of the world could agree to record all observations during a few years according to lunar instead of solar coordinates. Other problems will readily suggest themselves to you, and several might possibly be dealt with simultaneously.

The great reform I have in view is this: Before you observe make sure that your observations will be useful and will help to answer a definite question.

Though my frankly outspoken criticisms may not command universal assent, I hope you will agree that there is some foundation for them, and if so, the time is obviously not well chosen when observational science can be separated from its mathematical and experimental sisters. We hope that cosmical physics may remain an integral portion of Section A, and though we acknowledge our weaknesses we claim to have also something to teach.

I hope our proceedings this week may show that we can put aside observational detail and throw some light on the great and important problems with which our science is concerned.

Discussion on the Nebula surrounding Nova Persei, opened by A. R. Hinks *with an Exhibition of some Photographs from the Yerkes and Lick Observatories.*

The following Papers were read:—

1. *New Solar Radiation Recorder. By* Dr. W. E. Wilson, *F.R.S.*

Professor Callendar has used with his well-known electric recorder a form of receiver for solar radiation which consists of two coils of platinum wire wound on a mica frame. One of the coils is bright and the other black; they are protected from the rain by a glass shade. These two coils are the two arms of a Wheatstone bridge, and the balance is upset by the sun warming the black coil more than the bright. There are two disturbing factors in this form of receiver which are difficult to eliminate. First, the varying angle of the sun above the coils, which are fixed horizontally; and secondly, the amount of radiation received from the entire sky. This is constantly changing from the amount of cloud and haze present. To overcome these difficulties I have had a receiver made in which the coils are kept normal to the sun all day, and both coils are black and are sealed up in a vacuum tube. One of the coils alone receives the solar radiation, and that only from the sun, and a very small region of the surrounding sky. It was found that with the Callendar form of receiver it was quite impossible to calibrate the readings of the recorder with Ångström's phyheliometer, but with the new receiver the results can be accurately determined in calories per sq. cm. per minute.

2. *Search for ultra-Neptunian Planet. By* Dr. W. E. Wilson, *F.R.S.*

Last year at the meeting of the British Association at Glasgow Professor G. Forbes, F.R.S., read a paper in which he pointed out the possibility of there being an ultra-Neptunian planet.

In 1880 he made his first communication to the Royal Society of Edinburgh and pointed out that as Jupiter and Neptune have each a distinct group of comets whose aphelia lie close to their orbits, so in the same way there were two cometary groups which indicate that there were two planets beyond Neptune, one of which was at about one hundred times the mean distance of the earth from the sun. Dr. I. Roberts made a search for the planet in the position then computed by Forbes, but with a negative result. Since then Professor Forbes revised his calculations, and considered some points which he thought greatly strengthened his supposition in the reality of the unknown planet. He asked me to undertake another search for him with my 24″ reflector. This I gladly agreed to do, but I found that the field of the reflector was so small, the number of plates that it would take to cover the field so large, and the weather of this country so hopeless, that the work could not be done in a year. Sir David Solomons, Bart., then kindly offered to lend us a fine 6″ portrait lense of 28″ focus. I had a camera made for this to take plates 8½ × 6½, and it was bolted to the tube of the 24″ reflector. In May 1901 we took with this lense a sufficient number of plates to cover a region along the ecliptic each side of the theoretical place of the planet. Last February a second series of plates were taken in the early mornings before sunrise of the same positions, and these plates were superposed upon those of May 1901 and carefully examined for the planet, but I am sorry to say with a negative result. The plates all got with the full aperture one hour's exposure, so that unless the planet is a very faint one it ought to have been impressed on the plates. The planet Juno, although I did not know that it was in the field, was found at once. Although this search has been a negative one, it is, I think, a remarkable thing that both Dr. Todd of America and Professor Lau of Holland point out from the perturbations of Uranus the position of an ultra-Neptunian planet which is very close to the position given by Forbes. In fact, the plates taken by me, and which cover a region each side of the ecliptic from R.A. 10^h 50^m to 14^h, take in all these three positions.

3. *Minimum Sunspots and Terrestrial Magnetism.*
By the Rev. A. L. Cortie, *S.J., F.R.A.S.*

Sunspots and Magnets.

Rotation Number	Beginning	Greenwich Mean of Daily Disc Area		Stonyhurst	
		Spots	Faculæ	Mean of Magnetic Diurnal Range	Greatest Diurnal Range
606	1899, Jan. 15	271	399	10·7	32·0
607	" Feb. 11	154	402	15·5	28·7
608	" Mar. 10	38	218	16·2	37·5
609	" April 7	485	441	15·4	29·6
610	" May 4	159	344	14·7	37·5
611	" May 31	61	211	12·7	20·5
612	" June 27	173	410	15·6	65·0
613	" July 24	448	439	12·6	21·5
614	" Aug. 21	21	345	12·4	18·6
615	" Sept. 17	3	161	12·8	23·5
616	" Oct. 14	54	160	11·7	45·0
617	" Nov. 10	129	152	9·9	25·0
618	" Dec. 8	67	233	9·1	17·0
619	1900, Jan. 4	99	161	12·4	36·0
620	" Jan. 31	133	327	9·2	30·5
621	" Feb. 28	155	215	12·2	40·0
622	" Mar. 27	124	221	10·8	17·0
623	" April 23	253	312	11·7	52·0
624	" May 21	91	241	10·5	14·0
625	" June 17	163	104	10·4	14·0
626	" July 14	58	126	10·6	16·5
627	" Aug. 10	28	36	11·9	20·0
628	" Sept. 6	21	95	8·7	14·5
629	" Oct. 4	210	88	9·1	19·3
630	" Oct. 31	18	66	5·9	10·5
631	" Nov. 27	0	14	4·2	8·2
632	" Dec. 25	1	0	7·3	18·0
633	1901, Jan. 21	8	13	6·9	19·0
634	" Feb. 17	22	29	8·5	26·0
635	" Mar. 17	0	7	11·4	28·0
636	" April 13	0	0	10·4	19·3
637	" May 10	339	53	11·8	40·0
638	" June 6	70	34	10·7	20·0
639	" July 4	1	47	10·8	16·0
640	" July 31	0	6	11·1	28·0
641	" Aug. 27	0	2	10·3	30·5
642	" Sept. 23	10	8	9·0	24·0
643	" Oct. 21	29	94	7·0	13·0
644	" Nov. 17	51	4	5·0	12·0

Mr. Ellis has proved, from observations extending over the period 1841–1896, the strict concordance between the curves of sunspot frequency and those of the diurnal range of the declination and horizontal force magnets as to period and intensity. Lord Kelvin has proved theoretically that such concordance is not the outcome of efficient cause and effect. Father Sidgreaves has proved the same observationally from a detailed study of the greater solar and magnetic storms for the period 1881–1896, and advances a theory according to which the two phenomena are effects, and not necessarily conjoined, of one common cause. Professor Young contends that 'solar disturbances are not the cause of our magnetic storms, but only the cause of some of them,' meaning by 'a cause' an instrumental cause which releases the potential energy that directly affects the magnets. To examine this position a detailed study of the spots and faculæ on the sun and the diurnal range of the declination magnet has been made for the years 1899–1901, covering the minimum period of sunspots and magnetic storms, as the unravelling of the various storms and the perception of the concurrence of the two phenomena, if any, is rendered easier during such a period. The table prepared gives the mean daily disc-area for spots and faculæ for the thirty-eight solar rotations covered by the period under review, taken from the Greenwich records, and in parallel columns are also set out the mean daily diurnal ranges of the declination magnet and the greatest swing for each rotation. This table shows the existence of great anomalies between the sunspot and magnetic records. A detailed comparison of the greater spots on the sun and the greater magnetic movements only serves to confirm the existence of these departures from exact accord. The greatest spot of 1901, that of May 19–June 26, which was coincident with an unusual disturbance noticed in the solar corona on May 18, and was responsible for 74 per cent. of the total spotted area for the year, had no concordant greater magnetic movements; and, on the other hand, a greater magnetic movement of April 10, 1902, took place at a time of absolute solar calm. It is yet possible that solar spots are one of the instrumental causes of magnetic storms, but it is more likely that the two phenomena are correlated as connected, though sometimes independent, effects of one common cause.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

DEPARTMENT I.—MATHEMATICS.

The following Report and Papers were read:—

1. *Report on the Present State of the Theory of Point Groups.*

See Reports, p. 81.

2. *On the Partial Differential Equations of Mathematical Physics.*

By E. T. WHITTAKER, *M.A.*

The principal results contained in this paper were the following:—

1. The general solution of Laplace's equation

$$\frac{\partial^2 V}{\partial x^2}+\frac{\partial^2 V}{\partial y^2}+\frac{\partial^2 V}{\partial z^2}=0$$

is

$$V = \int_0^{2\pi} f(z + ix\cos u + iy\sin u,\, u)\, du$$

where f denotes an arbitrary function of the two arguments $z + ix\cos u + iy\sin u$ and u.

2. The particular solution of Laplace's equation in terms of Legendre functions, namely,

$$r^n\, P_n^m(\cos\theta)\cos m\phi\,;$$

where r, θ, ϕ are polar coordinates corresponding to the rectangular coordinates, x, y, z, is a multiple of

$$\int_0^{2\pi} (z + ix\cos u + iy\sin u)^n \cos mu\, du$$

3. The particular solution of Laplace's equation in terms of Bessel functions, namely,

$$e^{kz}\, J_m(k\rho)\cos m\phi\,;$$

where z, ρ, ϕ are cylindrical coordinates, is a multiple of

$$\int_0^{2\pi} e^{k(z + ix\cos u + iy\sin u)} \cos mu\, du$$

4. The general solution of the general partial differential equation of wave-motions

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = k^2 \frac{\partial^2 V}{\partial t^2}$$

is

$$V = \int_0^{2\pi}\int_0^{\pi} f\left(x\sin u\cos v + y\sin u\sin v + z\cos u + \frac{t}{k},\, u,\, v\right) du\, dv,$$

where f denotes an arbitrary function of the three arguments

$$x\sin u\cos v + y\sin u\sin v + z\cos u + \frac{t}{k},\quad u,\ \text{and}\ \ v.$$

5. The general solution of the equation

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = k^2 \frac{\partial^2 V}{\partial t^2},$$

as found in 4 can be expressed as a sum of particular solutions, each of the type

$$F(\lambda, u, v)\cos\left\{\lambda\left(x\sin u\cos v + y\sin u\sin v + z\cos u + \frac{t}{k}\right)\right\}$$

and each of these particular solutions can be interpreted physically as a simple uniform plane wave.[1]

3. *The Longitudinal Stability of Aërial Gliders.*

By Professor G. H. BRYAN, *Sc.D.*, *F.R.S.*

One of the most difficult questions connected with the problem of aërial navigation is the longitudinal stability of a machine supported on aëro-planes and aëro-curves. In this paper the author investigates the general conditions of stability for a gliding machine of any form, moving in a medium whose resistance follows any law whatever. The problem may be thus enunciated: A body is descending under gravity with uniform velocity in a straight line inclined at an angle a to the horizon in a resisting medium, the body being symmetrical about a vertical plane containing the line of descent; is this uniform rectilinear motion stable or unstable for small displacements in the vertical plane of motion? Choosing two rectangular axes through the centre of gravity, fixed in the body, the motion is defined by the velocity components u, v of the body, and the angle, θ, which one of the axes makes with the vertical at any instant. The resistances of the medium are reducible to forces X, Y along the axes and a couple, G, about the origin, all of which are functions of u, v, and $d\theta/dt$. The equations of motion being written down, the conditions for steady motion are obtained by putting u, v, and θ constant. If letters with the suffix 0 refer to steady motion the small oscillations or other motions in the neighbourhood of the steady motion are obtained by writing $u = u_0 + \delta u$, $v = v_0 + \delta v$, $\theta = \theta_0 + \delta\theta$, where δu, δv, $\delta\theta$ are small, and the corresponding expressions for the resistance-components are expressed in the form

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[1] The work will appear *in extenso* in the *Mathematische Annalen.*

$$X = X_0 + \delta u \frac{dX}{du} + \delta v \frac{dX}{dv} + \delta\theta' \frac{dX'}{d\theta}\,, \text{ where } \theta' = \frac{d\theta}{dt}$$

By putting δu, δv, $\delta\theta$ each proportional to e^{nt} and eliminating it is found that the values of n are determined by an equation of the fourth degree, and the character of the small motions in the neighbourhood of the steady motion depends on the nature of the roots of this biquadratic. In order that the steady motion may be stable, the roots of this equation must all have their real part negative, and this leads to five equations of condition which have been given by Routh in his essay on 'Stability of Motion.' Without going into numerical calculations the biquadratic character of the equation in n shows that a gliding machine may perform undulatory motions decreasing in amplitude corresponding to roots of the biquadratic with their real parts negative, and giving the impression that the machine is longitudinally stable; but there may be other roots corresponding to unstable motions which may cause the machine unexpectedly to capsize. The conclusion to be inferred from these results is that the future development of the problem of flight lies in the mathematical calculation for different types of machine of the quantities on which longitudinal stability depends, and that until aëronauts have fully worked out the mathematical investigations here sketched in outline it is useless for them to spend their money and risk their lives in further experiments with gliding machines.

4. *On Map-colouring.*[1] By Professor A. C. Dixon, *Sc.D.*

The number of ways, N, in which any given map can be coloured with four colours can be determined when this number is known for simpler maps.

Let N_{ab} . . . denote the number of ways in which the map can be coloured when simplified by throwing two or more provinces a, b . . . into one. Then the following formulæ hold good, and one of them can always be used:—

When a is triangular and is adjoined by b, c, d,

$$N = N_{ab} = N_{ac} = N_{ad}.$$

When a is quadrilateral and adjoined by b, c, d, e,

$$N = N_{bad} + N_{cae}.$$

When a is pentagonal and adjoined by b, c, d, e, f,

$$\begin{aligned} N &= N_{caf} + N_{cac} + N_{daf} - N_{ab} \\ &= \text{four other similar expressions.} \end{aligned}$$

The formulæ do not decide the question whether N is always >0.

If solid space is divided into compartments in an arbitrary way there is no limit to the number of colours needed to distinguish them.

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[1] The paper will be published in the *Messenger of Mathematics.*

5. *On the Newtonian Potential.* *By* Professor A. C. Dixon, *Sc.D.*

A vector $iX+jY+kZ$ in which X, Y, Z are functions of X, Y, Z, and which is reduced to zero by the operator ∇, appears to be at least one of the analogues for three-dimensioned space of a function of a complex variable.

If such an expression is called a Hamiltonian function, then triply periodic Hamiltonian functions can be readily constructed. The expression

$$\sum_{m_1=-\infty}^{\infty}\sum_{m_2=-\infty}^{\infty}\sum_{m_3=-\infty}^{\infty}\Big[f(x-p,\, y-q,\, z-r,\, m_1,\, m_2,\, m_3)$$
$$-f(x_0-p,\, y_0-q,\, z_0-r,\, m_1,\, m_2,\, m_3)-f(x-p_0,\, y-q_0,\, z-r_0,\, m_1,\, m_2,\, m_3)$$
$$+f(x_0-p_0,\, y_0-q_0,\, z_0-r_0,\, m_1,\, m_2,\, m_3)\Big]$$

where

$$f(x,\, y,\, z,\, m_1,\, m_2,\, m_3)$$

denotes

$$\nabla\Big[(x-m_1\alpha_1-m_2\alpha_2-m_3\alpha_3)^2+(y-m_1\beta_1-m_2\beta_2-m_3\beta_3)^2$$
$$+(z-m_1\gamma_1-m_2\gamma_2-m_3\gamma_3)^2\Big]^{-\frac{1}{2}}$$

is such a function. It has two isolated affinities of the simplest kind at $(p,\, q,\, r)$ $(p_0,\, q_0,\, r_0)$ and an arbitrary zero $(x_0,\, y_0,\, z_0)$, and by means of it other functions with more complicated singularities can be constructed.

In the theory which corresponds to that of the functions on a Riemann surface the use of Hamiltonian functions does not appear to lead to the simplest results, the reason being that ∇ is not invariant in regard to inversions. It seems better to take as analogous to a pair of conjugate functions two things of different nature, one being a simple and the other a double integral. Constant quantities lose their unique position and have to be considered as having a simple singularity at infinity in each sheet. The sheets are infinite coextensive spaces of three dimensions and are connected by doors which may be of various shapes. Circuits are of two kinds, one-dimensioned and two-dimensioned; to bar one of either kind one of the other kind must be added to the boundary.

On account of the disappearance of constant quantities there is nothing properly corresponding to the Abelian integrals of the first kind. The normal elementary potential of the second kind exists and will doubtless be the foundation of the theory, much of which is still to be worked out.

6. *The Discriminant of a Family of Curves or Surfaces.*[1] *By* Professor Bromwich, *M.A., and* R. W. H. T. Hudson, *M.A.*

This investigation contains all the simple results relating to the discriminant of a family of algebraic curves or surfaces which can be obtained without unduly specialising the family. The chief new results are connected with the question of osculating contact between the discriminant and some or all of the members of the family of curves. The ease with which properties of the discriminant may be demonstrated depends on the use of a notation which, as it does not involve the coordinates explicitly, is applicable to both two and three dimensions. The equation of the variable curve or surface is expanded in terms of the parameter t in the form

$$\psi\equiv A+Bt+Ct^2+\ .\ .\ .\ +Kt^n=0$$

and each of the polynomials A, B . . . is subdivided into homogeneous polynomials of degrees indicated by their suffixes; thus $A=A_0+A_1+A_2+$ . . . . The origin being taken on the discriminant we have $A_0=0$, $B_0=0$. The following theorems express the relation between the discriminant and the surface or curve $A=0$ near the origin.

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[1] *Quarterly Journal*, vol. xxxiv. p. 98.

(1) In general the shape of the discriminant is given by

$$0=A_1+A_2-\tfrac{1}{4}B_1^2/C_0$$

showing that the discriminant and the surface A have a common tangent plane $A_1=0$; further if $A_1\equiv 0$ both surfaces have conical points and the tangent cones touch along two generators. The same algebra when interpreted in two dimensions proves that the discriminant is an envelope, and that if it happens that the enveloped curve has a node at its point of intersection with the envelope, then the latter also has a node with a different pair of tangents in general.

(2) If $C_0=0$ the discriminant is

$$0=A_1^2+2A_1P_2+\tfrac{4}{27}B_1^3/D_0+\ \ldots$$

showing that in space the curve $\psi=0$, $\psi_t=0$, $\psi_{tt}=0$, is a cuspidal edge, and in the plane these points are cusps on the discriminant. Similarly it may be proved that the discriminant surface has a nodal line and the discriminant curve isolated nodes.

(3) If $B_1\equiv\lambda A_1$ the leading terms in the discriminant are

$$A_1+A_2+A_3+A_4-\tfrac{1}{4}(B_2-\lambda A_2)^2/C_0$$

which indicates that, in the plane, at isolated points of the envelope given by

$$\psi=0,\ \psi_t=0,\ \psi_x\psi_{yt}=\psi_y\psi_{xt}$$

the contact is of the third order, with a corresponding result in space.

(4) If $C_0=0$ and $D_0=0$, which happen at isolated points of the discriminant surface given by

$$\psi=0,\ \psi_t=0,\ \psi_{tt}=0,\ \psi_{ttt}=0,$$

three sheets of the surface have a common tangent plane, and the point of contact is a stationary point on the cuspidal edge, lying also on the nodal line.

Necessary and sufficient conditions that the envelope of a family of plane curves may *osculate* one member are found to be $B_1\equiv\lambda A_1$, $C_0=0$; or, in other words, that it should be possible to find x, y, t to satisfy

$$\psi=0,\ \psi_t=0,\ \psi_x\,\psi_{yt}=\psi_y\,\psi_{xt},\ \psi_{tt}=0,$$

and then the discriminant has two branches, each osculating the curve at this point. The case in which one of these branches is the enveloped curve is discussed.

When the conditions

$$\psi=0,\ \psi_t=0,\ \psi_{tt}=0$$

are satisfied at all points of a curve, this curve is an osculating envelope and occurs as a *squared* factor of the discriminant. In the case of the family of circles of curvature of a curve the discriminant contains as factors all the superosculating circles and the point circles at the foci and the curve itself as a squared factor.

These theorems in connection with plane curves are discussed also in a geometrical manner. One method consists in taking the parameter as a third coordinate and projecting the surface so obtained by rays parallel to the third axis. Another method is to regard a curve as a succession of near but isolated points, and in this way some easy intuitive proofs are given, which require, however, to be supplemented by more rigorous investigations. Finally, the analytical method is applied to obtain the usual results in connection with node- and cusp-loci.

7. *Matrix Notation in the Theory of Screws.*[1]
By R. W. H. T. HUDSON, *M.A.*

In this paper it is shown how the six coordinates of a screw may be arranged in the form of a four-rowed skew matrix, and that for many purposes the screw and also the corresponding infinitesimal linear point transformation may be represented by this matrix. Instances of this representation are given, and it is shown that the matrix PQ – QP represents a screw whose axes (in the language of elliptic geometry) cut those of the screws P and Q at right angles, and is connected with the displacement resulting from a succession of half-turns about P and Q in case these represent lines. The Peterson-Morley theorem, that the common normals of opposite sides of a rectangular skew hexagon have a common normal, is reduced to an identity among these matrices which corresponds to Jacobi's identity in the theory of continuous groups. The notation is useful in condensing the formulæ obtained in extending Darboux's theory of rotations depending on two parameters u, v, the chief results being expressed by the equation

$$\frac{\partial P}{\partial v} - \frac{\partial Q}{\partial u} + PQ - QP = 0,$$

where $Pdu + Qdv$ is the matrix of the instantaneous screw.

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8. *On Pluperfect Numbers. By* Lieut.-Colonel ALLAN CUNNINGHAM, *R.E.*

If $\int N$ denote the sum of the divisors of N (including both 1 and N), then N is called *Pluperfect* if $\int N \div N = \mu$ (an integer >2). A table of 85 *even* Pluperfects (P) is presented, of which 66 (computed by the author) are believed to be new.

A simple (somewhat tentative) method of evolving them has been found, viz. $P = 2^{q-1}.M_q.F$, where $M_q = (2^q - 1)$, and the form of F is suggested by M_q. One or more Pluperfects have been found for every value of q up to 39, except 33, 35, 36; also for $q = 45, 51, 62$. Some are very large numbers, containing more than twenty *different* primes; the largest is

$P = 2^{61}.M_q.F$, where $M_q = (2^{31} - 1).3.\frac{2^{31}+1}{3}$

$F = 3^7.5^4.7^2.11.13.19^2.23.59.71.79.127.157.379.757.43{,}331.3{,}033{,}169.$

No *odd* Pluperfect has been found. Among *even* Pluperfects—

1. None has been found of order $\mu > 6$.
2. Only *one* of order $\mu = 3$ has been found to arise from any one base (2^{q-1}).
3. From any one base (2^{q-1}) only two different orders (μ, μ') of Pluperfects have been found, viz. either (3, 4) (4, 5) (5, 6).

Two kinds of simple relations are found to exist between the orders (μ_r, μ'_r) of two sets of P where $P_r : P'_r$ is constant, viz.

If $P_r = 2^{q_r - 1}.X_r.f$, $P'_r = 2^{q_r - 1}.X_r.f'$, where f, f'. and all the X_r's are *odd*,

$$\frac{P_1}{P_1'} = \frac{P_2}{P_2'} = \ldots = \frac{P_r}{P_r'} = \frac{f}{f'}$$

then also $$\frac{\mu_1}{\mu_1'} = \frac{\mu_2}{\mu_2'} = \ldots = \frac{\mu_r}{\mu_r'} = \frac{\nu}{\nu'}, \text{ where } \nu = \int f \div f, \ \nu' = \int f' \div f',$$

provided f and f' are prime to every X_r.

Hence (1) if $\nu = \nu'$, then every $\mu_r = \mu'_r$; (2) if $\mu_1 = \mu_2 = \&c. = \mu_r$, then $\mu'_1 = \mu'_2 = \&c. = \mu'_r$.

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[1] *Messenger of Mathematics*, vol. xxxii. p. 51.

Hence, in either case, if one set (P_1 P_2, &c., P_r) be *given*, and also f, f', the other set becomes known.

Also a simple relation exists between P_{2q}, $P_{2q'}$ where $P_{2q} = 2^{2q-1} . M_{2q} . F$, $P_{2q'} = 2^{2q'-1} . M_{2q'} . F'$; then will $\mu = \mu'$ (if $q = q' + 2$), and $F = L_{q'} . F'$, provided q, M_q, L_q; q', $M_{q'}$, $L_{q'}$ be *all* prime and prime to F, F', where $M_q = 2^q - 1$ and $L_q = \frac{1}{3}(2^q + 1)$.

Hence if $P_{2q'}$ be *given*, P_{2q} is also known—Ex. $(q', q) =$ (5, 7) or (17, 19)

9. *On a Practical Rule for finding the Perimeter of an Ellipse.*
By Thomas Muir, *C.M.G., F.R.S.*

10. *The late J. Hamblin Smith's Rule for the Decimalisation of English Money.*[1] *By* J. D. Hamilton Dickson.

To divide by 96 is equivalent to multiplying by the series $\frac{1}{10^2} + \frac{4}{10^4} + \frac{4^2}{10^6} + \dots$ The late Mr. J. Hamblin Smith discovered a remarkable application of this to converting shillings and pence into decimals of a £. Starting with the two known first steps, namely, 'multiply the shillings by 5 and write the result in the first two places after the decimal point, then multiply the pence and ¼ pence by 4 and add the result (increased by 1 for 6*d.* or over) to the second and third places after the decimal point,' he proceeds thus: 'Multiply the last two decimals found at any stage of the process, after the first three have been obtained as above, by 4, take the digit in the ten's place of the product, append it to the decimals already found as the next decimal, and repeat the process; with the proviso that should the 4-product end with 48, 68, or 88, the digit in the ten's place is to be taken as 5, 7, or 9 respectively.' For example, 2*l.* 7*s.* 7¾*d.* gives at successive steps 2·382, (4 × 82 = 328 hence) 2·3822, (4 × 22 = **88** hence by proviso) 2·38229, (4 × 29 = 116 hence) 2·382291, then 2·3822916, and now 6 repeats, so that the result is 2·382291$\dot{6}$*l.*

A simple extension of the rule meets the case where (odd) eighths of a penny come into the sum of money. Calculate the first four places of the decimal for the sum which is one-eighth of a penny less than the given sum, *now* add 5 to the fourth decimal place (carrying unit to the third decimal place if necessary), and proceed according to the ordinary rule.

The converse of these operations is obvious, only three (or in the last case four) decimal places being necessary to get the answer correct to farthings.

For any divisor near and less than 100 (say from 99 to 93) a similar process is applicable, with a suitable change of the multiplier 4. Further, the process is applicable to any dividend by a slight extension of the list of provisos. The rule is, to divide any number by one of these divisors (say 97), multiply the last two digits of the quotient found at any stage of the process by the associated multiplier (here 3), add the digits in the ten's and unit's places of the product to the next two following digits of the dividend, considered as being in ten's and unit's places as they stand, take the digit in the ten's place of this sum and append it to the part of the quotient already found, thus extending the quotient by one digit, then repeat the process; subject to the proviso that if the last two digits in the sum

97
68, 78, 88, 98
39, 49, 59, 69, 79, 89, 99

be contained in the annexed table (for 97), the new digit to be added in the quotient is to be 4, 5, 6, 7, 8, 9, *t* respectively, where *t* is 10. There are similar tables for other divisors.

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[1] *Transactions Edinburgh Mathematical Society*, 1902–1903.

The origin of these limitations is easily found; the limitation 78 (say), which is to be read 'seven hundred and eighty something,' is already, at 780, more than $8 \times 97 = 776$, therefore instead of 7 write 8 as the next digit in the quotient.

Again, these limitations are closely connected with the usual long division process as shown below. It will be noticed that, in general, the digit in the ten's place of each remainder (before bringing down the next digit of the dividend) is the next digit in the quotient, unless altered by the limitations. [These are put in heavier type for clearness.]

97)**6**7001312(690735
582
880
873
071
000
713
679
341
291
502
485

Mr. Hamblin Smith noted that the process is true for any factor of such a divisor. Thus to divide by 33, the associated multiplier is 1, and the quotient can be instantly written down; to divide by 7, 14, 49, the multiplier is 2, which recalls the decimal for $\frac{1}{7}$.

The process is capable of even further extension; as, for instance, to such divisors as 997, or 103 with a slight alteration.

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11. *A Theorem in Determinants.* *By* A. A. Robb.

Department II.—Physics.

The following Papers were read:—

1. *Note on the Variation of the Specific Heat of Mercury with Temperature: Experiments by the Continuous-flow Method of Calorimetry.* *By* Howard T. Barnes, *M.A.Sc., D.Sc., and* H. Lester Cooke, *B.A.*

Since the communication to the Royal Society in 1900 of the work of one of the authors on the specific heat of water it has been possible to continue the experiments by the continuous-flow method of calorimetry to the case of mercury. These measurements, which include an interval of temperature between 0° and 90° C., have been carried out with essentially the same apparatus as previously used for water, and with the same electrical standards. The first determinations which were made for mercury by this method were made by Professor Callendar and one of the authors during the summer of 1897, just previous to the Toronto meeting of the British Association. The results then obtained with our preliminary apparatus were entirely revised and recalculated three years later. It was the intention of one of the authors to include them in his paper on the specific heat of water, since they afforded a most satisfactory verification of the theory of the method. Deeming it advisable, however, to redetermine the value of the specific heat, and to extend the experiments over as large a range of temperature as possible with more refined apparatus, it was decided to reserve the publication until later. These results, which were obtained from our preliminary experiments, stand in close agreement with the authors' later results, the error being less than one part in 1,000, although carried out with different electrical standards and a calorimeter differing materially in design from the one recently employed.

The present series of experiments was made with a calorimeter in every way similar to the 'water' calorimeter described by Professor Callendar and one of the authors,[1] with the exception that the flow tube was smaller in bore. The rest of the apparatus was essentially the same with a few minor changes.

Preliminary Results.

These results, obtained in 1897, we reproduce here through the courtesy of Professor Callendar, who was one of the observers at that time. They were obtained with jacket circulation system, without temperature regulator, so that observations taken at the temperature of the laboratory only could be successfully carried out. The calorimeter employed had a flow tube 1 metre long and 1 mm. in diameter coiled in a spiral as described by Professor Callendar.[2] The thermometers were pair A described by one of the authors.[3] The Clark cells were S_1 and S_5, and the resistance standard was one of the manganin coils described in section 3 *b*, *supra*.

The only three determinations made at room temperature are as follows:—

Date	Mean Temperature	Js.	s.
July 9, 1897	25·0	·13898	·033174
„ 14 „	27·4	·13899	·033177
„ 19 „	28·0	·13900	·033179

Recent Results.

The later results were obtained with improved apparatus. The calorimeter had a flow tube about 1 mm. in diameter and 45 cm. long. The thermometers were pair E.

The mica frame resistance standards and Clark cells X_2 and X_1 were used. Redeterminations were made of the value of the resistances in terms of the standard platinum-silver coils in the possession of the laboratory, which showed that they had remained unchanged to one in 100,000 since the series of tests taken for the measurements for water, and already described. The Clark cells were found to have lowered a little in value since 1900, and a correction was necessary in order to reduce to the mean of a number of new cells. The history of these original crystal cells, made in 1895, to which X_2 and X_{11} belong, shows that from comparisons with new cells made from time to time they have steadily lowered in value. A new comparison was also made to several Weston cadmium cells. There is no reason to doubt that the values assumed for the electrical standards are the same as those assumed in the measurement of the specific heat of water, to much better than one in 10,000. The thermometers were also recalibrated severa times, as well as further determinations made of the box coil corrections. Hence, even assuming that any error exists for the values assigned to the units used in the calculations for water, the specific heat of mercury may be expressed from these measurements in terms of water, and any possible error eliminated from the relative value. Since also the same apparatus has been used, and as far as possible the same experimental arrangements, systematic sources of error in the method are to a large extent avoided.

The absolute values of the thermal capacity of mercury are given in the following table for different temperatures, calculated by the method already described by one of the authors.

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[1] *Brit. Assoc. Rep.*, 1898.

[2] *Phil. Trans.*, vol. cxcix. (1902).

[3] *Ibid.*, vol. cxcix. p. 182 (1902), sec. 3 *c*.

The results are in terms of the nitrogen thermometer and are uncorrected for the temperature gradient in the flow tube as described by Professor Callendar.

Since this correction is small, and is partly balanced by the correction to the standard hydrogen scale, the results will not be changed much by its application, and the variation with temperature will remain practically unaffected.

Mean Temp.	Js.	S (J = 4·1891)	Formula
2·85	·140056	·033435	·14003
2·93	·140085	·033440	·14002
4·42	·139927	·033405	·13996
18·37	·139459	·033291	·13939
24·52	·139182	·033224	·13915
31·68	·138890	·033156	·13889
32·14	·138873	·033151	·13888
32·41	·138846	·033141	·13887
36·59	·138753	·033121	·13873
45·0	·138447	·033050	·13847
53·39	·138225	·032997	·13822
65·22	·137942	·032929	·13791
83·89	·137479	·032818	·13752

In fig. 1 is given a plot of the observations, the vertical scale being the value

$$\frac{Js - 0{\cdot}140}{0{\cdot}140}$$

The preliminary results are also included.

It will be seen that the specific heat decreases with rise in temperature, suggesting that portion of the curve for water between 10° and 20°.

Results over a wider interval of temperature could not be conveniently taken with the present apparatus. We purpose continuing the work to much higher temperatures immediately in order to trace the course of the curve as the boiling-point of the mercury is reached.

The equation representing the change of Js and shown by the curve in the figure reads:

$$Js_t = Js_0 - 4{\cdot}462 \times 10^{-5}\, t + {\cdot}0157 \times 10^{-5}\, t^2$$

where

$$Js_0 = {\cdot}140154$$

The value of the specific heat in terms of water has been calculated, taking the value of J equal to 4·1891 for a thermal unit at 15°·5, which was the temperature recommended by Griffiths at the Paris Congress in 1900, as being suitable for the selections of the thermal unit.

The temperature expression of the specific heat reads:

$$S_t = S_o - 1{\cdot}074 \times 10^{-5}\, t + {\cdot}00385 \times 10^{-5}\, t^2$$

or

$$\frac{S_t - S_o}{S_o} = -{\cdot}000321\, t + {\cdot}00000115\, t^2$$

where

$$S_o = {\cdot}033458.$$

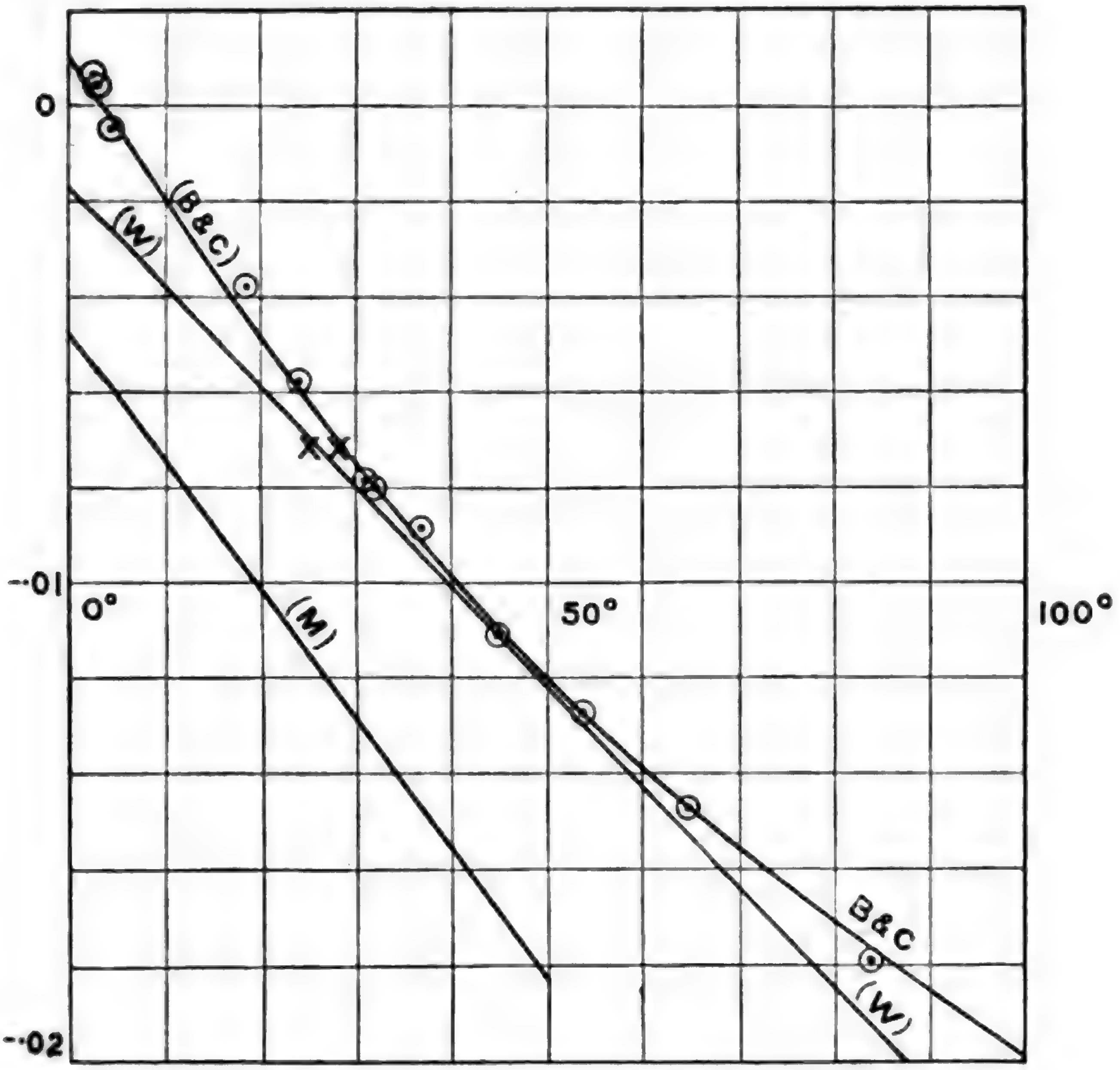
This gives for the temperature coefficient at any temperature t the expression

$$\frac{d}{dt}\left(\frac{S_t}{S_o}\right) = -{\cdot}000321 + {\cdot}00000230\, t$$

and for the average change per degree at 50° the value $-{\cdot}0000069$.

Compared with the Work of other Observers.

The value of the specific heat obtained by Regnault,[1] and so universally adopted, i.e., ·03332, is found to be in agreement with our determination at 13°·3, and very close to the value at the ordinary temperature of laboratory work. The value was obtained over a range 10° to 100° in terms of a thermal unit at 10°, and is considerably in excess of our value for the same mean temperature. Experiments to determine the variation with temperature indicated an increase in specific heat with increasing temperature.



⊙ Observations of Barnes and Cooke, 1902.
× Observations of Callendar and Barnes, 1897.
B & C Formula proposed by Barnes and Cooke.
W Formula proposed by Winkelmann.
M Formula proposed by Milthaler.

Winkelmann[2] carried out an extensive series of experiments by the method of mixture, to determine the temperature coefficient, and was the first to show that the specific heat decreased as the temperature increased. This result being so exceptional at the time, and so contrary to the results for other liquids, the author was inclined to regard it as doubtful until he finally verified the first experiments by a second series, in which he eliminated certain sources of error. Two ranges of temperature were taken, the first between 20° and 50° C., and the second between 26° and 142° C. The average variation from these measurements was found to be − ·0000069. No absolute measurements were made, but the value obtained by Regnault was assumed.

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[1] *Pogg. Ann.*, vol. li. p. 44 (1840), and vol. li. p. 238 (1840).

[2] *Ibid.*, vol. clix. p. 152 (1876).

The formula proposed by Winkelmann is shown in the figure (W). This reads:

$$S_t = S_0 - \cdot0000069\, t.$$

The remarkable agreement with the average change from our determinations is shown very clearly in the figure, a total decrease of 2 per cent. between 0° and 100° being given both by Winkelmann's results and our own.

The position of the curve in the figure shows that the temperature at which Winkelmann assumed Regnault's value, which in one case was the mean from 16° to 20°, and in the second case from 13° to 25°, is very nearly equal to the temperature at which our value is exactly equal to Regnault's, *i.e.*, 13°·3 C.

Pettersson and Hedelius [1] obtained ·033266 between 0 and 5°, ·033262 between 5° and 16°, ·033300 between 5° and 26°, and ·033290 between 5° and 36° C. These results were all expressed in terms of a thermal unit for water at 0°.

The measurements were repeated more accurately by J. Milthaler,[2] who used a similar method to the previous investigators, *i.e.*, the method of mixture. This author verified Winkelmann's results and showed that the specific heat apparently decreased with rise of temperature, the average decrease from his measurements being ·0000092, which is somewhat greater than Winkelmann obtained.

The formula proposed by Milthaler is shown in the figure (M). The slope of the curve is about the same as the slope of our curve at the low temperature; but since Milthaler supposed this formula to apply as high as 200°, its agreement for the low temperatures is more a matter of coincidence. The position of the line in the figure shows that the value of Pettersson and Hedelius which he assumed is too small at 0° compared to our values, but this value will be increased when corrected to a thermal unit for water at 15°·5 instead of 0°, and will then be brought into much closer agreement.

2. *Some Experiments on Radiation and Absorption: a Preliminary Study for a Standard of Light.* *By* J. E. PETAVEL.

The first part of the paper refers to some determinations of the intrinsic brilliancy of iridium and platinum-iridium at their temperature of fusion.

It has been previously shown [3] that if t be the temperature centigrade and b the intrinsic brilliancy in candle-power per square centimetre

Formula I.

$$t = 400 + 889{\cdot}6 \sqrt[6\cdot9]{b}$$

The photometric observations and calculated temperatures of fusion are given in the following table:—

—	Intrinsic brilliancy in candle power per square centimetre	Melting-point in degrees centigrade from Formula I.
Platinum	19	1,763
Platinum-iridium (25 per cent. Ir.).	34	1,883
Iridium	290	2,423

The temperature of a radiating body may also be estimated by a second method.

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[1] *Jour. für prak. Chem.*, vol. xxiv. p. 135 (1881).

[2] *Wied. Ann.*, vol. xxxvi. p. 897 (1889).

[3] See *Phil. Trans.*, cxci. 501.

The percentage of the total radiation passing through two centimetres of water has been measured at various temperatures. It is shown that for platinum above 1,000° C. this quantity is approximately a linear function of the temperature, the relation being:

Formula II.

$$t = 872 + 81{\cdot}03\,h$$

where t is the temperature centigrade; h the percentage of total radiation passing through a two-centimetre water-trough having quartz sides two millimetres thick.

—	Percentage of total radiation transmitted through two centimetres of water	Melting-point in degrees centigrade from Formula II.
Palladium	8·84	1,593
Platinum	11·0	1,770
Platinum-iridium (25 per cent. Ir.).	12·2	1,868

The first formula only applies strictly to a platinum radiator; the second is at the best a rough approximation.

They may, however, be of some practical use in many cases where very accurate results are not necessary, or where the temperatures are too high to be directly measured.

In the second part of the paper the absorption curves of a number of substances, including glass, quartz, fluorspar, water, benzol, bisulphide of carbon, &c., are given.

The curves refer to the radiation emitted by incandescent platinum, the temperature range being from 1,000 to 1,700° C.

For all these bodies the percentage of heat tramsmitted increases with the temperature.

One exception to the rule is noted—namely, black fluorspar.

In experimental work it is frequently desirable to maintain the temperature of a radiating body constant; the anomalous absorption of black fluorspar provides a ready means by which this may be done.

If two thermopiles, one measuring the radiation through, say, glass, the other through black fluorspar, are connected in opposition, there will be a critical temperature at which the resulting galvanometer deflection will be zero. The actual temperature at which this will occur will depend on the relative thickness of the plates and on the relative distance of the thermopiles, but for a given disposition of the apparatus it will always be the same.

Some experiments are now being made with a standard of light based in principle on the above results.

3. *Some Observations on Equations of State.* *By* H. H. F. Hyndman.

1. Equations of state may be obtained by two methods—one by strictly theoretical deductions from certain given premises checked as much as possible by experimental results, the other frankly empirical and including as many experimental results as possible in a systematic manner.

The only equations considered here will be those which are in accordance with the 'law' of corresponding states, and they may be generally expressed in the following form:

$$f(p, v, t, A, B, C) = 0$$

where A, B, C were independent constants directly expressible in terms of the gas constant R and the three critical constants $(p, v, t)_k$.

The problem is usually attempted by first forming the virial equation for the molecules, which may be written

$$pv = \tfrac{1}{3} m\overline{c}^{2} + \tfrac{1}{3}\Sigma vf(v) - \tfrac{1}{3}\Sigma v\mathrm{F}(v)$$

and endeavouring to evaluate the terms.

The first may be taken equal to RT. The second expresses the collision of the molecules, and is in general a function of v and T. The third expresses the attraction of the molecules, and is also a function of v and T. In many cases equations have been deduced in accordance with the law by making certain simplifications in the assumptions mentioned, but more specialisation introduces more constants.

The equations of Boltzmann and Reinganum are the most satisfactory at present known. The cyclical equation of v. d. Waals endeavours to advance by considering the virial of the atoms in the molecule, but it is implicit and leads to some false deductions, *e.g.*, that $b=f(v)$ only.

The empirical method has been most completely followed by Kamerlingh Onnes[1] from Amagat's 1893 values for H_2, O_2, N_2, CO_2.
It is given in the form

$$\lambda\mathfrak{p}\mathfrak{v} = \mathfrak{A} + \frac{\mathfrak{B}}{\lambda\mathfrak{v}} + \frac{\mathfrak{C}}{\lambda^{2}\mathfrak{v}^{2}} + \ . \ . \ . \ + \frac{\mathfrak{F}}{\lambda^{8}\mathfrak{v}^{8}}$$

where

$$\mathfrak{A} = \frac{\mathfrak{A}}{\mathrm{T}_c}(1 + a_{\mathrm{H}}t),\ \mathfrak{B} = b_1\tau + b_2 + b_3\frac{1}{\tau} + b_4\frac{1}{\tau^{3}},\ \text{\&c.}$$

$$\lambda = \left(\frac{pv}{\mathrm{T}}\right)_c \ \mathfrak{p},\ \mathfrak{v},\ \tau \text{ are reduced } p,\ v,\ t.$$

Since v is here expressed in terms of the theoretical normal volume, the equation agrees strictly with the law. It expresses with considerable exactness the reduced isotherm from $\tau = 12{\cdot}29$ to $0{\cdot}897$, and $p = 3{,}000$ At to 1.

2. A strict adherence to the law of corresponding states for the deduction of equations of state is quite arbitrary, and is only justified by its general applicability and our lack of accurate knowledge.

The burden of the proof of the law $\frac{\mathrm{RT}_k}{p_k v_k} = \mathrm{K}$ falls upon the critical data which, as shown recently by Matthias, are in general very uncertain, and no advance can be made until better results are to hand.

To form an opinion as to the theoretical causes of divergence the various axioms used for the deduction of equations of state are considered, and some possible directions of advance indicated.

An extension of the law is needed if the value of K for argon can be taken as anywhere near correct, for then the values of K would vary from 2·67, equal to that of v. d. Waals' original equation, to more than 3·4, the value given by his cyclical equation, and found experimentally for oxygen and nitrogen.

3. The values of the critical constants depend largely upon the exact experimental conditions, and even their theoretical meaning is questioned.

De Heen, Galitzine, and Traube consider that under their conditions of experiment the fluid is not to be treated as homogeneous, but as a mixture of two species of molecules, and the composition of which depends upon the temperature. The critical point is then merely a point where the two species can mix in all proportions, and where a sudden transformation from one to the other occurs.

This assumes that liquid, or at any rate a meniscus, can be formed above the critical point.

A discussion of Traube's work shows that his theory is not in accordance with his and de Heen's observations, even if these are considered as free from experimental errors due to the neglect of certain precautions such as stirring.

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[1] *Communications*, Leiden, No. 71, June 1901.

4. The work of Amagat and Young has sufficiently indicated the general course of the isothermals and their general correspondence. Work is now wanted which is sufficiently accurate and extended to show the differences from the law shown by various groups of substances. For many problems an accuracy of $\frac{1}{1000}$ at least is required, and this can only be attained by the greatest care in the measurement of pressure volume and temperature. Such has been the object and the result of the work carried on at Leiden for some years.

The isotherms of argon would enable many problems to be attacked owing to the probable physical constancy of the molecule, and would form standard isothermals. Present results are rarely standard, as they usually depend upon the readings of a gas manometer filled with air or nitrogen, and thus are influenced by the uncertainty in the isotherms of these gases. The only really accurate isotherms at present known are those of hydrogen and oxygen, of which gases the latter is unsuitable for standard instruments. A systematic use of the hydrogen manometer at a standard temperature would obviate the difficulty.

Starting from the hydrogen isotherm[1] at 20° C. as standard, the isotherms of oxygen at pressures up to 60 ats. and at temperatures between 20° and −120° C. have been studied, and the isotherms at 20°, 15·6°, 0·0° published.[2] The other isotherms will shortly be given, together with very accurate determinations of the critical constants, which will make possible an accurate equation of four terms for oxygen. The other data required to completely check the differences in the general equation are not to hand, except the compressibilities of hydrogen[3] at a few pressures and at temperatures between 0·0° and −196° C., where hydrogen corresponds to oxygen between 0·0° and 100·0° C., and hence where the minimum of pv can be found experimentally. The numbers allow the value of $\mathfrak{B}$ to be fairly accurately fixed.

4. *On the Graphical Representation of Ramsay and Young's Law for the Comparison of Vapours at Equal Pressures. By* Professor J. D. Everett, *F.R.S.*

5. *Dependence of Pitch of Minute Closed Pipes on Wind Pressure.*[4]

By C. S. Myers, *M.D.*

The author gave a preliminary account of recent experiments on the varying pitch of tones produced from Galton whistles according to the wind pressure employed. He showed that for every pipe-length there is an optimum wind pressure for the production of the highest tone; that under certain conditions the pressure can be so adjusted as to give no audible sound, while a note can yet be heard if the pressure is in the least degree increased above or diminished below that point; and that, under other conditions, increase of wind pressure may produce a sudden decrease instead of the more common rise of pitch.

6. *A Lens for Ultra-violet Therapy. By* J. William Gifford.

Reference is made to a photographic doublet of quartz and calcite described at the Bradford Meeting in 1900, and a triple achromatised similarly for the chemical and visual maxima (wave-lengths 2748 and 5607) is recommended for the purpose.

The chief requirements are—

1. That the calcite lens be protected.

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[1] Schalkwijk, *Communications*, Leiden, No. 70.

[2] Onnes and Hyndman, *ibid.*, Leiden, Nos. 69 and 78.

[3] *Ibid.*, Leiden, No. 82, January 1903.

[4] Full data are given in *Journ. of Physiol.*, vol. xxviii., No. 6, 1902.

2. That rays should pass through the calcite lens parallel to its axis, which should correspond with the axis of the crystal.

3. That the lens should be achromatic for the wave-lengths chosen.

4. That as far as possible the combination should be aplanatic, but in any case the aberration should be the same for both wave-lengths.

5. That only two lens tools should be necessary, so that it may not be expensive.

These requirements are satisfied by a triple consisting of two outer bi-convex lenses of quartz enclosing an equi-concave of calcite. The details follow:—

Radii. R and $S'' = \pm 2{\cdot}10739$. S, R', S' and $R'' = \pm 1{\cdot}95416$.
Thickness. t and $t'' = {\cdot}33763$ (quartz). $t' = {\cdot}0750$ (calcite).
Diameter = 1·50.
Mean principal focus = 2·33897
" conjugate " = 4·67748 for wave-length 2748
" " " = 4·67839 " " 5607

Outstanding chromatic error = ·00091

Spherical aberration wave-length 2748 = − ·78027
" " " 5607 = − ·81752

The spherical aberration may be reduced to vanishing-point for the heights chosen by separating the first two lenses, but owing to the loss of light by reflection at the air-space it is preferred to make optical contact by cementing all inner surfaces with glycerine. The spherical aberration is not as serious as would appear, the height taken near the vertex representing a very small area.

To avoid double refraction the distances of spark and object from the lens must be the same.

It is best to have one right-handed and one left-handed quartz element.

Calcite becomes opaque to ultra-violet beyond wave-length 2145, but the skin and tissues are already very opaque at wave-length 2500.

7. *Mr. Petavel's Recording Gauge applied to Ordnance and Small Arms.*[1]

By Captain J. BRUCE-KINGSMILL, *R.A.*

After a brief consideration of some of the problems of ballistics, an account was given of the various methods by which in modern practice the properties of explosives are determined.

Although the oldest type of heat engine, the gun was till recently the least well understood. It was not until the crusher gauge had been brought out by Sir Andrew Noble (then Captain Noble, R.A.), when a member of the Explosives Committee of 1869, that the maximum pressure could be accurately measured.

Thanks to his exhaustive researches and those of Abel, Vieille, and Berthelot, thanks also to the uninterrupted experimental work which has been carried out independently at such centres as Woolwich, Elswick, Essen, by the Creusot Company, &c., the necessary data have gradually been determined, and the design of artillery (which at one time was a matter of guesswork and rule-of-thumb) has become an exact science.

But the use of higher pressures and more powerful artillery has of late made a further advance necessary.

The rapid development of the steam-engine and the high efficiency attained to by it may to a large extent be attributed to the use of the indicator by means of which the internal working of the engine can be ascertained.

The need of a corresponding device for use with artillery was soon felt.

To meet this want several instruments have been devised.

Sir Andrew Noble conceived the ingenious idea of relieving the spring of the indicator at or near the maximum pressures, and thus obtaining an excellent record of the rate of fall of pressure in a closed vessel.

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[1] Published *in extenso* in *Engineering*, March 13, 1903.

Vieille has designed two instruments.

In the first the record of a tuning-fork is inscribed on a plate supported by a stiff spring, which is bent by the pressure of the explosion.

In the second the motion of the spring itself is directly inscribed on a revolving cylinder.

The deflections in either case are very small, the records being read by means of a microscope.

In the instrument with which the present paper is more especially concerned the spring of the indicator is replaced by a metal tube, the deflection corresponding to the elastic compression of the material.

The deflection is magnified by a very light lever, the curve being recorded either photographically or stylographically on a revolving cylinder.

The advantages of the instrument are twofold.

1st. The time period is sufficiently short for an accurate record of the fastest explosions to be obtained.

2nd. The records are of the dimensions of an ordinary steam-engine diagram, and can therefore be measured directly with sufficient accuracy.

This instrument will give an accurate and easily read *time-space* curve.

8. *On an Improvement upon Huygens' Construction.*
By G. Johnstone Stoney, *M.A., D.Sc., F.R.S.*

The hypothesis that underlies Huygens' construction is that if S be a surface with which the wave-fronts of an undulation come successively to coincide, and if we call K and Q the spaces on either side of this surface, the direction of propagation being from K to Q, then, instead of the actual wave-motion in space Q, it is permissible, as an hypothesis which is legitimate for some purposes, to substitute the simultaneous advance into space Q of undulations of spherical wavelets which have started simultaneously in the same phase from the several puncta (or physical points) of surface S.

The improvement consists in using, instead of the surface S, a stratum of a wave-length in thickness, and assuming that undulations of spherical wavelets of equal intensity start simultaneously at the instant $t=\tau$ from all the puncta of this stratum *in the phases in which the original undulation reaches those puncta at that instant of time.*

This hypothesis can be justified as a simplification, which for almost all purposes is legitimate, of the complete resolution into spherical wavelets of which use was made in a paper read by the present writer before the British Association in 1859, and published in the 'Transactions' of the Royal Irish Academy for 1860, p. 37.

While Huygens' more crude construction gives a correct result only in the direction of propagation, furnishing results that deviate from the correct result in inclined directions, and suggesting false results for backward directions, the amended construction gives almost exactly correct results in all directions.

Moreover, with the new construction it is legitimate to place the stratum S oblique to the wave-front as well as coincident with it. When in the oblique position the thickness of the stratum is to be $\lambda \cos \theta$, θ being the inclination of S to the wave-front.

9. *How to apply the Resolution of Light into Undulations of Flat Wavelets to the Investigation of Optical Phenomena.*[1] *By* G. Johnstone Stoney, *M.A., D.Sc., F.R.S.*

The light undulations that propagate themselves forward through a uniform isotropic medium may be resolved in an infinity of different ways, and among them into undulations of convex, or of concave, or of flat wavelets. That a resolution into uniform flat wavelets is always possible is proved in a paper published at page 570 of last year's Report of the British Association,[1] and the present paper is devoted to explaining a convenient way of making practical use of this method of resolution. The resolution of light into undulations of uniform flat wavelets has the great advantage over every other resolution that each of these flat wavelet components does not undergo alteration as it advances through the medium.

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[1] *Phil. Mag.*, February 1903.

Instead of making use of rectangular or polar coordinates, the position in space and the motion of each of the component undulations are referred to a fixed hemisphere, for which the name of *reference hemisphere* is suggested. Each point on the convex side of this hemisphere is the *guide-point* of two undulations of flat wavelets, one travelling outwards along the radius to that point and the other travelling in the opposite direction. If, then, we know whether the undulation is outward bound or inward bound, the position of its guide-point upon the surface of the reference hemisphere indicates both the orientation of the wave-fronts and the direction in which they are being propagated.

These particulars are even more conveniently indicated by the orthogonal projection of the guide-point upon the flat circular base of the hemisphere. This projection may be called the *index-point* of the undulation, and the pattern presented by the index-points of all the undulations that we have occasion to deal with in any problem may be called their *indicator diagram*.

From this construction a number of propositions are deduced, which make it easy to apply the above method of analysis to the solution of many optical problems, including some which either cannot, or cannot without difficulty, be treated by any of the usual methods.

It also suggests interesting experimental verifications, and makes what is seen in these experiments intelligible in a degree that they have not hitherto been.

The same proof furnishes the more general theorem—that light traversing *any* uniform transparent medium, whether isotropic or doubly refracting, may be resolved into undulations of flat wavelets—and that the *reference surface* by which the orientations, velocities, and states of polarisation of these undulations can be indicated is, in general, half of the wave-surface of that medium. This reference surface becomes a simple hemisphere, and at the same time loses its power of

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[1] At p. 617 of the *Monthly Notices* of the Royal Astronomical Society, issued in September 1902, Mr. E. T. Whittaker has given another and extremely elegant proof of this theorem by showing that every solution of the equation

$$\nabla^2 V = \frac{1}{k^2}\frac{\partial^2 V}{\partial t^2}$$

can be analysed into undulations of flat wavelets advancing with the speed k.

This proof has the advantage of deriving the resolution directly from the fundamental differential equation of wave-motion where the speed of propagation is the same in all directions and is a constant as regards x, y, z, and t; a condition which, as Clerk Maxwell showed, is fulfilled by electromagnetic waves in an isotropic medium whenever we may assume that the product of the two inductive capacities of the medium is independent of the intensity of the alternations of electromagnetic stress, notwithstanding that in dispersing media it is not independent of their periodic time. This is doubtless a correct assumption in the case of those electromagnetic waves which constitute any light that our eyes can see.

On the other hand, the proof given in the B.A. Report of 1901, which is based upon MacCullagh's Principle of Reversal, has two advantages of much importance to physicists: that it furnishes useful details of the resolution, and that it exhibits the relation in which the resolution into flat wavelets stands to neighbouring resolutions into nearly flat wavelets, which are what practically have to be dealt with in making experiments. Moreover, the proof by the Principle of Reversal has another considerable advantage in that it is applicable to doubly refracting media in which k, the speed of propagation, is a function of the vector, as well as to isotropic media, in which it is the same in all directions. It is fortunate, therefore, that we are in possession of both proofs.

furnishing information about the state of polarisation in the case of isotropic media, with which the paper of which this is an abstract more particularly deals.

By an *undulation* is to be understood an uninterrupted train of waves which are all alike—of the same wave-length intensity and state of polarisation, and each undulation occupying the whole of space for all time. Accordingly, if the medium be of limited extent, we must, for the purposes of this resolution, take into account what would occur throughout an extension of the medium. At the same time it is convenient in practical problems, and is legitimate, to consider separately what happens within a prescribed space and at a definite time. The resolution of a given distribution of light into its component undulations of flat wavelets is *unique* in the same sense in which resolutions by Fourier's Theorem, or into Spherical Harmonics, are unique.

Department III.—Astronomy and Cosmical Physics.

The following Papers and Reports were read:—

1. *Illustrations obtained by Photography of the Evolution of Stellar Systems.* *By* Isaac Roberts, *D.Sc., F.R.S.*

2. *Radiation in Meteorology.* *By* W. N. Shaw, *F.R.S.*

The purpose of the paper was to invite meteorological observers to make special observations of the effect of radiation upon thermometers exposed under different meteorological conditions as regards cloud. The author explained that the effect upon a cloud of gain or loss of heat by radiation was to lower or raise the temperature of the cloud according to the temperature gradient, and pointed out as a consequence that the specific heat of a cloud might be positive or negative, and that for the particular case of adiabatic gradient the specific heat of air is negative and indefinitely large. Hence it followed that the tracing of changes of temperature by means of radiation observations might be of great assistance in tracing the changes in the thickness of floating clouds.

He then indicated the nature of the observations upon radiation which are already included in the meteorological routine of a second order station, and suggested the comparison of the black bulb with the simultaneous reading of the screened dry bulb in various conditions of weather, and also pointed out some unexplained phenomena connected with radiation which arose from a comparison of the records of a photographic sunshine recorder with those of a Campbell-Stokes instrument.

3. *On the Figure of the Earth.* *By* Major S. G. Burrard, *R.E.*

Deflections of the plumb-line placed, and have continued to place, insuperable obstacles in the way of correct determinations of the figure of the earth. The pains we take in observing for latitude seem thrown away: the correctness of our result must depend on the direction of gravity, and at no place on the earth can the direction of gravity be relied upon to indicate the true vertical. We could measure the distance from Londonderry to Waterford within 2 or 3 feet; we could observe their latitudes within 5 or 6 feet; but deflections of gravity at Londonderry and Waterford might, without being extraordinary, throw us out by 800 feet.

About 1860 Russian surveyors made the discovery at Moscow that deflections of the plumb-line existed on flat unbroken plains; that these deflections varied sixteen seconds in 18 miles where no mountain was visible. This discovery showed a local underground variation in the density of the earth's crust. It had a profound influence on all subsequent discussion, and deflections of the plumb-line were everywhere now readily attributed to local underground causes. But the generalisation which followed the Moscow discovery was too hasty; to the best of my belief, no second plain has been discovered where deflections vary sixteen seconds in 18 miles. On the other hand we have discovered within the last two years the existence of an underground and invisible chain of extreme density stretching across India from east to west for a thousand miles, and which may possibly be disturbing the direction of gravity throughout the country. The discovery of this underground chain brings home to us how little we really know of mountain attraction. The underground chain of density underlies the Vindhyan range of mountains: whilst then we have, in obedience to theory, been endeavouring to prove that the Himalaya Mountains overlie great deficiencies of matter, we have stumbled on the fact, unforeseen by theorists, that the Vindhya Mountains overlie great excesses.

It has been said that the arcs of India are Great Britain's largest contribution to the science of geodesy. It will not be out of place if I refer to their critics. It has been repeatedly stated that the presence of the Himalayan Mountains detracts from the value of the Indian arcs. This statement originated in the account of the triangulation of Great Britain. The author of a popular handbook describes the Himalayas as a reproach to the arcs of India. Now if mountains lead us to anticipate systematic error, do not oceans do so also? Where then is the country, and where the arc, where systematic error is not to be anticipated? A theory has been devised that the visible deficiency of oceans is compensated by the condensation and contraction of submarine strata, but it rests on insufficient data. Every survey has discovered coast-stations where plumb-lines are deflected seawards, and the theory of condensation has been built on them. As an example we may suppose a seaward deflection of five seconds observed on the coast of Mayo, whilst no deflections are found in Roscommon. Would this be evidence that the strata underlying the Atlantic are condensed? Would not a wide and distant ocean affect Mayo and Roscommon similarly? If the Atlantic Ocean were causing the deflection in Mayo, it would, I submit, affect plumb-lines in Germany and Russia. The systematic error caused by the Atlantic Ocean cannot be gauged from an observation on the Irish coast. Its determination requires masses of observations spread over Europe. Whilst we can observe at the foot and heart of the Himalayas, no observations can be taken over Atlantic depths nor even on the brink of its submerged cliffs. The real edge of the Atlantic is not at the visible Irish coast-line, but far out to sea. If we had never approached nearer to the Himalayas than the Irish coast-line is to the Atlantic, we should have been unable even to discuss the subject of mountain attraction, and oceanic effects can only be studied by the aid of lessons from mountains.

Instead, then, of reproaching the arcs of India, we must discover the systematic errors affecting them. The aim of our geodesists must not be confined to the determination of an imaginary mean figure for the earth; and though it would be fantastic to think of investigating all the many elevations and depressions that disfigure the level surface of the sea, we must at any rate endeavour to obtain a definite idea of the order of their magnitude, whether their heights and depths, above and below the mean surface, are to be estimated in feet or thousands of feet. If this endeavour be regarded as a desirable and legitimate aim, the scientific value of arcs affected by mountain attraction will be recognised.

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4. *Report on Seismological Investigations.*—See Reports, p. 59.

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5. *Report on the Investigations of the Upper Atmosphere by Means of Kites.*—See Reports, p. 77.

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6. *Report on Magnetic Observations at Falmouth Observatory.*
See Reports, p. 75.

7. *Report on Meteorological Observations on Ben Nevis.* See Reports, p. 93.

8. *Report on the Comparison and Reduction of Magnetic Observations.* See Reports, p. 58.

TUESDAY, SEPTEMBER 16.

DEPARTMENT I.—PHYSICS.

The following Papers were read:—

1. *Animal Thermostat.* *By* Lord KELVIN.

A thermostat is an apparatus, or instrument, for automatically maintaining a constant temperature in a space, or a piece of solid or fluid matter with varying temperatures in the surrounding matter.

Where and of what character is the thermostat by which the temperature of the human body is kept at about 98°·4 Fahrenheit? It has long been known that the source of heat drawn upon by this thermostat is the combination of food with oxygen, when the surrounding temperature is below that of the body. The discovery worked out by Lavoisier, Laplace, and Magnus still holds good, that the place of the combination is chiefly in tissues surrounding minute tubes through which blood circulates to all parts of the body, and not mainly in the place where the furnace is stoked by the introduction of food, in the shape of chyle, into the circulation, nor in the lungs where oxygen is absorbed into the blood. It is possible, however, that the controlling mechanism by which the temperature is kept to 98°·4 may be in the central parts, about, or in, the pumping station (the heart); but it may seem more probable that it is directly effective in the tissues or small blood-vessels in which the combination of oxygen with food takes place.

But how does the thermostat act when the surrounding temperature is anything above 98°·4 and the atmosphere saturated with moisture so that perspiration could not evaporate from the surface? If the breath goes out at the temperature of the body and contains carbonic acid, what becomes of the heat of combustion of the carbon thus taken from the food? It seems as if a large surplus of heat must somehow be carried out by the breath: because heat is being conducted in from without across the skin all over the body; and the food and drink we may suppose to be at the surrounding temperature when taken into the body.

Much is wanted in the way of experiment and observation to test the temperature of healthy persons living in a thoroughly moist atmosphere at temperatures considerably above 98°·4; and to find how much, if at all, it is above 98°·4. Experiments might also, safely I believe, be tried on healthy persons by keeping them for considerable times in baths at 106° Fahr. with surrounding atmosphere at the same temperature and thoroughly saturated with vapour of water. The temperature of the mouth (as ordinarily taken in medical practice) should be tested every two minutes or so. The temperature and quantity and moisture and carbonic acid of the breath should also be measured as accurately as possible.

P.S., December 5, 1902.—Since the communication of this note my attention has been called to a most interesting paper by Dr. Adair Crawford in the 'Philosophical Transactions' for 1871 (Hutton's Abridgments, vol. xv. p. 147), *Experiments on the Power that Animals, when placed in certain circumstances, possess of producing Cold.* Dr. Crawford's title expresses perfectly the question to which I desired to call the attention of the British Association; and, as contributions towards answering it, he describes some very important discoveries by experiment in the following passage, which I quote from his paper.

'The following experiments were made with a view to determine with greater certainty the causes of the refrigeration in the above instances.[1] To discover whether the cold produced by a living animal placed in air hotter than its body be not greater than what would be produced by an equal mass of inanimate matter, Dr. Crawford took a living and a dead frog, equally moist, and of nearly the same bulk, the former of which was at 67°, the latter at 68°, and laid them on flannel in air which had been raised to 106°. In the course of twenty-five minutes the order of heating was as annexed.[2]

Min.	Air	Dead Frog	Living Frog
	°	°	°
In 1	—	70½	67½
„ 2	102	72	68
„ 3	100	72½	69½
„ 4	100	73	70
„ 25	95	81¼	78¼

'The thermometer being introduced into the stomach, the internal heat of the animals was found to be the same with that at the surface. Hence it appears that the living frog acquired heat more slowly than the dead one. Its vital powers must therefore have been active in the generation of cold.

'To determine whether the cold produced in this instance depended solely on the evaporation from the surface, increased by the energy of the vital principle, a living and dead frog were taken at 75°, and were immersed in water at 98°, the living frog being placed in such a situation as not to interrupt respiration.[3]

Min.	Dead Frog	Living Frog
	°	°
In 1	85	81
„ 2	88½	85
„ 3	90½	87
„ 5	91½	89
„ 6	91½	89
„ 8	91½	89

'These experiments prove that living frogs have the faculty of resisting heat, or producing cold, when immersed in warm water; and the experiments of Dr. Fordyce prove that the human body has the same power in a moist as well as in a dry air; it is therefore highly probable that this power does not depend solely on evaporation.

'It may not be improper here to observe that healthy frogs in an atmosphere above 70° keep themselves at a lower temperature than the external air, but are warmer internally than at the surface of their bodies; for when the air was 77° a frog was found to be 68°, the thermometer being placed in contact with the skin; but when the thermometer was introduced into the stomach, it rose to 70½°. It may also be proper to mention that an animal of the same species placed in water at 61° was found to be nearly 61¼° at the surface, and internally it was 66½°. These observations are meant to extend only to frogs living in air or water at the common temperature of the atmosphere in summer. They do not hold with respect to those animals when plunged suddenly into a warm medium, as in the preceding experiments.

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[1] Observations by Governor Ellis in 1758; teachings of Dr. Cullen prior to 1765; very daring and important experiments by Dr. Fordyce on himself in heated rooms, communicated to the Royal Society of London in 1774.

[2] In the two following experiments the thermometers were placed in contact with the skin of the animals under the axillæ.—ORIG.

[3] In the above experiment the water, by the cold frogs and by the agitation which it suffered during their immersion, was reduced nearly to 91½°.—ORIG.

'To determine whether animals also have the power of producing cold when surrounded with water above the standard of their natural heat, a dog at 102° was immersed in water at 114°, the thermometer being closely applied to the skin under the axilla, and so much of his head being uncovered as to allow him a free respiration.

In 5 minutes the dog was 108°, water 112°
„ 6 „ „ 109, „ 112
„ 11 „ „ 108, „ 112, the respiration having become very rapid.
„ 13 „ „ 108, „ 112, the respiration being still more rapid.
„ 30 „ „ 109, „ 112, the animal then in a very languid state.

'Small quantities of blood being drawn from the femoral artery, and from a contiguous vein, the temperature did not seem to be much increased above the natural standard, and the sensible heat of the former appeared to be nearly the same with that of the latter.

'In this experiment a remarkable change was produced in the appearance of the venous blood; for it is well known that in the natural state the colour of the venous blood is a dark red, that of the arterial being light and florid; but after the animal, in the experiment in question, had been immersed in warm water for half an hour the venous blood assumed very nearly the hue of the arterial, and resembled it so much in appearance that it was difficult to distinguish between them. It is proper to observe that the animal which was the subject of this experiment had been previously weakened by losing a considerable quantity of blood a few days before. When the experiment was repeated with dogs which had not suffered a similar evacuation the change in the colour of the venous blood was more gradual; but in every instance in which the trial was made, and it was repeated six times, the alteration was so remarkable that the blood which was taken in the warm bath could readily be distinguished from that which had been taken from the same vein before immersion by those who were unacquainted with the motives or circumstances of the experiment.

'To discover whether a similar change would be produced in the colour of the venous blood in hot air, a dog at 102° was placed in air at 134°. In ten minutes the temperature of the dog was 104½°, that of the air being 130°. In fifteen minutes the dog was 106°, the air 130°. A small quantity of blood was then taken from the jugular vein, the colour of which was sensibly altered, being much lighter than in the natural state. The effect produced by external heat on the colour of the venous blood seems to confirm the following opinion which was first suggested by my worthy and ingenious friend, Mr. Wilson, of Glasgow. Admitting that the sensible heat of animals depends on the separation of absolute heat from the blood by means of its union with the phlogistic principle in the minute vessels, may there not be a certain temperature at which that fluid is no longer capable of combining with phlogiston, and at which it must of course cease to give off heat? It was partly with a view to investigate the truth of this opinion that Dr. Crawford was led to make the experiments recited above.'

These views of Dr. Crawford and 'his worthy and ingenious friend, Mr. Wilson,[1] of Glasgow,' express, about as well as it was possible to express before the chemical discoveries of carbonic acid and oxygen, the now well-known truth that oxygen carried along, but not chemically combined, with food in the arteries, combines with the carried food in the capillaries or surrounding tissues in the outlying regions, and yields carbonic acid to the returning venous blood: this carbonic acid giving the venous blood its darker colour, and being ultimately rejected from the blood and from the body through the lungs, and carried away in the breath. Crawford's very important discovery that the venous blood of a dog which had been kept for some time in a hot-water bath at 112° Fahr. was almost undistinguishable from its arterial blood, proves that it contained much less than the normal amount of carbonic acid, and that it may even have contained no carbonic acid at all. Chemical analysis of the breath in the circumstances would be most interesting; and it is to be hoped that this chemical experiment will be tried on men. It seems indeed, with our present want of experimental knowledge of animal thermodynamics, and with such knowledge as we have of physical thermodynamics, that the breath of an animal kept for a considerable time in a hot-water bath above the natural temperature of its body may be found to contain no carbonic acid at all. But even this would not explain the *generation of cold* which Dr. Crawford so clearly and pertinaciously pointed out. Very careful experimenting ought to be performed to ascertain whether or not there is a surplus of oxgyen in the breath; more oxygen breathed out than taken in. If this is found to be the case, the *animal cold* would be explained by deoxidation (unburning) of matter within the body. If this matter is wholly or partly water, free hydrogen might be found in the breath; or the hydrogen of water left by oxygen might be disposed of in the body, in less highly oxygenated compounds than those existing when animal heat is wanted for keeping up the temperature of the body, or when the body is dynamically doing work.

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[1] Who, no doubt, was Dr. Alex. Wilson, first professor of astronomy in the University of Glasgow (1760–1784); best known now for his ingenious views regarding sunspots.

2. *On the Application of the Method of Entropy to Radiant Energy.*

By J. LARMOR, *Sec.R.S.*

The entropy of a material system has been defined by Boltzmann as the logarithm of the probability of its molecular configuration; and this definition has recently been applied by Planck to the radiation in an enclosure, thereby obtaining a law for the constitution of natural radiation at a given temperature, which is in close accord with the facts. His argument involves simple vibrators in the region, and it is their fortuitous arrangement that enters. It was explained that various difficulties attending this procedure are evaded, and the same result attained, by discarding the vibrators and considering the random distribution of the permanent element of the radiation itself, among the differential elements of volume of the enclosure, somewhat on the analogy of the Newtonian corpuscular theory of optics.[1]

3. *On the Relation of Voltaic Potential Differences to Temperature.*

By J. LARMOR, *Sec.R.S.*

It was shown, by means of Carnot's principle, that if material substances have no special affinity for electricity, voltaic potential differences should be proportional to the absolute temperature. The experiments of Majorana with liquid air as a cooling agent show that they actually fall at a more rapid rate than this law would give, from which it is inferred that imparting an electric charge to a metal involves absorption of heat owing to direct affinity between its molecules and the charge.

4. *Does Motion through the Ether cause Double Refraction?*

By Lord RAYLEIGH, *F.R.S.*

5. *Report on Electrical Standards.*—See Reports, p. 53.

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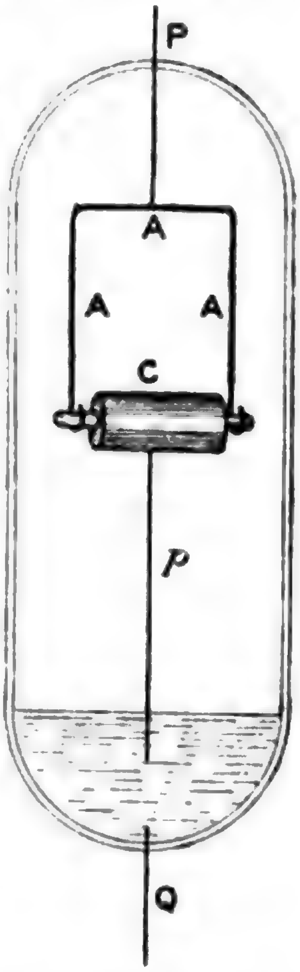
[1] Cf. *Brit. Assoc. Report*, 1900.

6. *Magnetic Detectors in Space Telegraphy.*[1]
By Professor ERNEST WILSON.

This is a subject which has attracted considerable attention since Mr. Marconi has found that as a substitute for the coherer magnetic detectors give very consistent results over long distances. Rutherford was probably the first to make a scientific investigation into the effect which high frequency electric currents have upon the magnetism of a bundle of wires previously magnetised. The author of the paper also made experiments with magnetic detectors in 1897. One form of his detector consists of a ring of fine iron wires the magnetism of which can be continuously reversed by a local battery. A telephone connected to a coil wound on the ring is used to receive the minute transient electric currents produced when another coil on the ring receives the electric impulses from a distant transmitter. Using straight iron wires on which the coils are wound the author finds that the effects are increased by submitting the specimen to pull and twist stress, and also by heating it to a temperature a little below that at which iron ceases to be a magnetisable substance.

7. *A New Receiver for Hertzian Oscillations.*
By Professor G. M. MINCHIN, *F.R.S.*

About three years ago I constructed a receiver ('coherer') for electromagnetic oscillations, in which the effective bodies are carbon and aluminium. The description is as follows:—C is a cylinder of electric-light carbon about $\frac{1}{4}$ inch in diameter, and about the same length, terminating in two spindles; AAA is an aluminium wire, about $\frac{1}{20}$ inch in diameter, bent round at its ends into two circular arcs into which the narrow spindles of the carbon cylinder fit somewhat loosely. The cylinder C is attached to a platinum wire *p*, and the aluminium wire to a platinum wire P. The system *p*CAAA is inserted into a glass tube containing mercury at its closed end, and into this mercury the wire *p* dips. The wire P passes through a narrow neck at the other end of the tube. The mercury is boiled so as to expel the air from the tube, and when the air is expelled the narrow neck is closed and P sealed into the tube. Another platinum wire Q was initially sealed into the lower end, so as to make contact with the mercury.



Thus the system of carbon cylinder and aluminium wire is now sealed into and suspended inside a glass tube containing mercury and its vapour.

Tried in the laboratory with the oscillations produced by an electrical gas lighter, this proved to be a very sensitive receiver.

It was simply placed as a resistance in the circuit of a weak dry cell and a telephone, and the oscillations of the gas lighter affected it at the distance of about 30 or 40 feet.

No tapper is necessary to break the coherence.

When I made this receiver and wished to try it over long distances my induction coil most unfortunately broke down; and, for one reason or another, I was unable to try it until the beginning of August 1902.

The oscillator consisted of a rectangular sheet of zinc, about 3 feet by 6 feet, elevated to the top of a metallic telegraph post about 25 feet high. The receiving surface was a sheet of copper, of about half the area of the zinc, attached to a wooden pole about 12 feet high at a distance of about 600 yards from the oscillator, the intervening space being occupied by trees and hilly ground, so that the receiver was screened by this ground from the oscillator.

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[1] See the *Electrician*, September 26, 1902.

When a telephone was placed in the receiving circuit the separate dots and dashes sent from the oscillator were distinctly heard without any failure or intermission.

The addition of a fishing-rod 12 feet long, through the rings of which was passed a stout iron wire, to the top of the receiving copper surface, so as to increase the virtual height of this surface, made a marked improvement in loudness, the various dots and dashes being now heard without putting the telephone to the ear. The decoherence was perfectly good for the telephone, but when the telephone was replaced by a relay there was not sufficient automatic decoherence; a slight tap was generally necessary.

I have always used telephones as the indicators of oscillations, and employed three or four coherers in parallel in the telephonic circuit.

With the exception of the coherer just described, I have never hit upon one which automatically and satisfactorily decohered, and I do not know if any coherer hitherto discovered decoheres automatically with a relay.

The most severe test of any coherer occurs when the coherer is employed close to the oscillator—that is, in the laboratory—and it appears to me that the above coherer stands this test remarkably well when used with a telephone.

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8. *A Graphical Method of Determining the Discharge Curve of a Condenser through a variable Self-induction.* *By* E. W. MARCHANT, *D.Sc.*

The method employed is an extension of that described by Dr. Sumpner in a paper to the 'Phil. Mag.' in 1897 for determining the rise in the current through a coil of variable self-induction. The method consists in graphically determining successive values of $\frac{di}{dt}$, the rate of change of current for the discharge.

$$\frac{di}{dt}=\frac{-i-\frac{\int i dt}{\mathrm{CR}}+\frac{\mathrm{E}_0}{\mathrm{R}}}{\frac{\mathrm{L}}{\mathrm{R}}+\frac{i}{\mathrm{R}}\frac{d\mathrm{L}}{di}}$$

where i = current in amperes.
C = capacity of condenser in farads.
R = resistance of circuit in ohms.
L = self-induction of circuit in henrys.
E_0 = initial P.D. to which the condenser was charged.

The method was first tested for the case in which the self-induction is constant, the time interval between successive determinations of the value of $\frac{di}{dt}$ being so chosen that $\frac{dt}{\mathrm{CR}}$ is a simple number K, so that the quantity $\frac{\int i dt}{\mathrm{CR}} = \mathrm{K}i$, for the time dt and can be represented as a fraction of i. Plotting in this way it was found that the periodic time for an oscillatory discharge was obtained accurately to within 1 per cent., and that the maximum value of the current was determined accurately to within 2 per cent. For a discharge through a circuit of larger resistance it was found that the period of oscillation was again accurate to within 1 per cent., and that the damping effect, due to the resistance and the displacement of the time of maximum current from an instant midway between two zero values, was well shown.

The method was then applied to the determination of the discharge curve through a coil having a soft iron core, and with which a number of experiments had been made. Three curves were shown for the same circuit, in which the voltages applied to the condenser were respectively 9,400 (2·5 mm. spark) 2,350, and 450. In the first two cases the current wave after clinging to the zero line becomes approximately sinusoidal, while in the third the curve is sharply peaked. The periodic times given by these determinations were shown to be in approximate agreement with those found experimentally. The phenomena due to hysteresis in the iron core were also shown in the third curve.

9. *On Luminosity and the Kinetic Theory.* *By* J. BUTLER BURKE, *M.A.*

The object of this paper is to show that the phenomena of luminosity are accompanied by, or dependent upon, the formation of large molecular aggregates which act as centres of intense molecular force, and that the luminosity results from the bombardment of these by the free corpuscles in the luminous body, which in virtue of the powerful centres of force acquire a great velocity under their attraction, producing collisions of considerable violence with them. In the case of phosphorescent bodies the time during which these aggregates continue to exist is very much longer than in ordinary non-phosphorescent substances when they are broken up almost instantaneously.

The effect of molecular forces in the phenomena of phosphorescence is doubtless one of great importance, as solids are far more phosphorescent than liquids, and these far more so than gases, in which the phenomena of phosphorescence is of very rare occurrence.

There is conclusive evidence that separate molecules exist during the process of the change of refrangibility of light. This can be shown by Stokes' method of crossed prisms, by which means it is found that the period of the phosphorescent light is entirely independent of that of the exciting light; the exciting rays may be very high up in the ultra-violet, and yet the spectrum of the phosphorescent light is the same as if the exciting light were in the blue or violet. This is a most remarkable fact, and proves that the luminous vibrations are not forced. Again, from the change of absorption during phosphorescence [1] it can be deduced that the luminosity is due to the formation, for the time being, of new periods under the influence of the exciting light either by dissociation or by association.

An explanation is given, based on this theory of large aggregates, of the Newall pressure glow, and of the discharge of negative electrification by phosphorescent bodies.

The existence of separate phosphorescent molecules is shown by the fact that the after-glow in a gas can be greatly increased in brilliancy and duration by letting the phosphorescent gas diffuse through narrow metal tubing from the bulb in which the discharge is produced into another similar bulb.

The phosphorescent molecules therefore do not appear to carry a free charge of electricity, yet the glowing molecules produce ionisation in the gas.[2]

The existence of separate molecules of an ephemeral nature during luminosity, to which it is due, shows that the free periods in a luminous gas need not be the same as those in a non-luminous one, and therefore that the ratio of the specific heats as determined for a non-luminous gas does not give the number of degrees of freedom when the systems of molecular aggregates herein considered exist, during which brief interval of time the physical and chemical properties of the substance should be altered.

The ratio of the specific heats for a gas in this state of molecular aggregation will be quite different from that of the gas in its ordinary state. The state of molecular condensation may be brought about by the action of ultra-violet light by the passage of an electric discharge through the gas, or by molecular interactions, giving rise to chemical actions.

10. *The Physical Aspects of a Theory of Colour Vision.*
By F. W. EDRIDGE-GREEN, *M.D., F.R.C.S.*

The view which I wish to bring forward is that each optic nerve fibre is able to convey impulses corresponding to all kinds of light—that is to say, a very similar condition exists in the impulses which are transmitted along the optic nerve to that which is accepted for waves of light previous to their entering the eye. The limitation of the number of colour-sensations was thought to be necessary because it seemed physically impossible that a single fibre of the optic nerve could convey all waves of light. The facts of colour vision can only be satisfactorily explained on the assumption that each optic nerve fibre does convey impulses corresponding to all waves of light. It occurred to me that if there were a transforming apparatus in the eye we could explain the facts. The telephone shows how this may be accomplished in the case of sound. I saw that the retina was constructed in a manner theoretically perfect from this point of view. The percipient layer of the retina is made up of two kinds of elements, the rods and the cones. The portion of the retina corresponding to the central portion of the field of vision contains only cones. External to this spot the cones are arranged with one or more rings of rods round them, the single ring being round those cones which are nearest to the central portion. In the rods there is a rose-coloured substance, the visual purple, which is very sensitive to light. This photo-chemical substance is found exclusively in the rods. I assumed that light falling upon the eye liberated the visual purple from the rods, just as heat would an ointment, and a photograph is formed. The decomposition of the visual purple by light chemically stimulates the ends of the cones, and a visual impulse is set up which is conveyed through the optic nerve fibres to the brain. I have examined the retinas of several monkeys after they had been kept in a dark room, and found that the visual purple was to be seen in the yellow spot, but situated between, and not in, the cones. This view gives a reason for a great many facts which were previously inexplicable. For instance, a bright light may fall upon the fovea (the centre of the yellow spot) without producing any sensation, and a perceptible interval elapses before we are able to see with the yellow spot, after the remainder of the retina, the fovea being the last point to convey a sensation of light. The first fact we should expect, the cones being insensitive to light; the second corresponds to the diffusion into the yellow spot of the visual purple. All the facts of colour mixing, contrast, and after-images can be explained by the hypothesis that the visual purple is the visual substance. A positive rose-coloured after-image can be obtained after white light or any spectral colour. The ordinary explanation of this—namely, that the action of the hypothetical red and violet fibres persists longer than those for green—cannot be true, because it is exceedingly difficult to obtain this after-image after spectral red, and very easy to see it after green. It would be against the whole principle of the theory that the red fibres should be excited most efficiently by green. But if we assume that the visual purple is the visual substance, then we have an easy explanation of the facts.

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[1] See Burke, *Phil. Trans.*, vol. cxci. (A).

[2] Burke, *Phil. Mag.*, March and April 1901.

The fibres of the optic nerve pass to the visual centre. I have assumed that the visual centre transmits to the mind impressions of white light, and that by it objects are seen monochromatically, as in a photograph. The visual centre is, therefore, acted upon by impulses caused by all rays of light, the colour-perceiving centre being concerned with the quality of the impulse within the power of perceiving differences possessed by that centre, or portions of that centre.

I will now apply this theory to colour-blindness, and it will be seen that it gives a simple explanation of the facts.

Cases of colour-blindness may be divided into two classes, which are quite separate and distinct from each other, though both may be present in the same person. In the first class there is light as well as colour loss. In the second class the perception of light is the same as the normal sighted but there is a defect in the perception of colour. In the first class certain rays are either not perceived at all or very imperfectly. Both these classes are represented by analogous conditions in the perception of sounds. The first class of the colour-blind is represented by those who are unable to hear very high or very low notes. The second class of the colour-blind is represented by those who possess what is commonly called a defective musical ear. Colour-blind individuals belonging to this class can be arranged in a series. At one end of this series are the normal sighted, and at the other the totally colour-blind. The colours appear at the points of greatest difference, and I have classified the colour-blind in accordance with the number of colours which they see in the spectrum. If the normal sighted be designated hexachromic, those who see five colours may be called pentachromic; those who see four, tetrachromic; those who see three, trichromic;

those who see two, dichromic; and the totally colour-blind, monochromic. There are many degrees included in the dichromic class. There may or may not be a neutral band, and this is widest in those cases approaching most nearly to total colour-blindness. I have recorded a case of a patient who was colour-blind with one eye. It is an interesting fact that for form vision the colour-blind eye was much the better of the two, and he could recognise fine lines in the spectrum with this eye which were not visible to the other. He saw the two ends of the spectrum tinged with colour and the remainder grey. It will be noticed that his colour sensations were limited to the extreme red and the extreme violet—namely, those colours which present the greatest physical contrast to each other. Neither the red nor the violet appeared of the nature of a primary colour, but gave the impression that they were largely diluted with grey. A theory of colour vision must account for a case of this kind and also for the other varieties and degrees of colour-blindness. The trichromic are a very important class, and any theory must account for the fact that they see yellow as red-green and blue as violet-green. As we should theoretically expect, when there is shortening of the spectrum the centres of the colours are moved towards the unshortened side.

I will conclude by showing how this theory will explain the trichromatism of normal colour vision. It also explains why certain persons see spectral yellow as red-green and spectral blue as green-violet. In past ages all saw the rainbow made up of only three colours—red, green, and violet. When a new colour appeared between the red and green (yellow) it is obvious that a mixture of red and green would give rise, not to red-green, but to the colour which had replaced it—namely, yellow.

11. *Light Aluminium Tubes.* *By* F. H. NALDER.

When engaged in experimental work many are confronted with the difficulty of obtaining stiff pointers, which at the same time are light. In the production of commercial measuring instruments this same difficulty has arisen, and makers are being compelled to find other means for making pointers than the old one of putting a flute on a piece of thin flat metal. The method generally employed is to bend up a piece of thin metal in the form of a tube with a loose seam; but a better plan is to use seamless drawn aluminium tubes which can be made with walls having a small thickness, such as one-thousandth of an inch. The specimens submitted vary from this thickness with different diameters up to three-thousandths of an inch or more.

DEPARTMENT II.—ASTRONOMY AND COSMICAL PHYSICS.

The following Papers were read:—

1. *Exhibition of Celestial Photographs from the Yerkes Observatory.*
By A. R. HINKS, *M.A.*

2. *Possible Changes on the Lunar Surface.* *By* S. A. SAUNDER, *M.A.*

In 1864 a strong committee of the British Association was appointed for the purpose of 'Mapping the Surface of the Moon.' In their first report they laid stress on the necessity for thoroughly remapping and describing the surface, inasmuch as 'in the present state of selenography we cannot say of any object, "It is new."' The whole or parts of the surface had been previously mapped or drawn by Hevelius, Riccioli, Dominic Cassini, Schröter, Lohrmann, Beer and Mädler; but whilst there were considerable differences between them, even in the larger formations, the minute detail was very inadequately represented by all. In 1866 Schmidt announced that Linné had lost the crater form with which he had previously been acquainted, and was to be seen only as a small white cloudy spot.

This announcement drew the attention of astronomers all over Europe both to the spot itself and to the older records. It was found that, whilst the usual appearance was that of the spot described by Schmidt, it was possible to make out, under low illumination, a small conical hill, a minute crater, and the remains of a larger shallow crater, some 4″ or 5″ in diameter. Lohrmann had drawn a crater here which he describes as very deep and visible under every illumination. Mädler had drawn a similar crater, had frequently observed it, and remembered having seen shadow in the interior with the sun at an altitude of 30°. Schmidt himself had also seen and drawn a similar object. There was, however, found a drawing of Schröter's which some have taken to represent very much what we see now; others have thought that it represents something different from this: and others again that he simply omitted to draw the crater at all, similar omissions being found in other drawings of his. The drawing has, however, been held by many to throw doubt upon the reality of the change, although the positive assertions of Lohrmann, Mädler, and Schmidt appear to me to be conclusive.

Another change on the surface was announced in 1877 by Klein, who found a black spot, three miles in diameter, a little north of Hyginus, and therefore nearly in the centre of the visible disc and in one of the best known regions of the moon. Many drawings were examined, but no observation of the spot could be found previous to 1876; subsequently to its discovery it was always a conspicuous object within thirty-six hours of either sunrise or sunset. The most practised observers agreed that it was due to a shallow bowl-shaped depression, and Schmidt, Klein, and Neison were all of opinion that it was the result of an actual physical change on the surface.

There are many other instances of suspected change, though the evidence is not so strong as in the cases quoted.

Changes of a different character are those which are periodical in their nature, the period being that of a lunar day. Some of these were known and described by Mädler, who rejected the opinion held by many that they were due to vegetation, on the ground that vegetation without air or water was beyond our comprehension. A number of these spots have been studied by Professor W. H. Pickering, who believes that the moon has sufficient atmosphere to support some possibly low types of vegetation, and that the changes to be seen in such spots as those in Alphonsus and Atlas are really indications of vegetable life.

These and other instances of possible change on the surface clearly lay upon us the duty of so mapping and describing every discoverable feature on the moon that future generations may be able to recognise change in any part of the surface. Even the best photographs show only the larger formations, those in which change is least likely to be noted. The more minute detail is still accessible only to visual observation, which must be prolonged over many lunations if all that can be seen is to be recorded. This is too much for anyone to undertake for the whole surface, but it may be done for a few formations by any amateur who will devote himself consistently and perseveringly to the work, first laying down from the photographs all that can be found on them, and then filling in the details at the telescope with the help of a micrometer.

3. *The Relative Apparent Motions of Bright and Faint Stars.*

By Professor H. H. Turner.

1. Sir David Gill finds for zone −40° to −52° that bright stars are increasing their R.A. about $+0^{\mathrm{s}}\cdot0012$ per magnitude per year with reference to faint, suggesting a rotation of bright stars as a whole. This result is arrived at by comparing catalogues made by eye observations from which the effect of 'magnitude-equation' has only partially been eliminated.

2. Photographs of the same region, taken at dates sufficiently separated, would show this motion without any interference from 'magnitude-equation.'

3. The photographs taken at Oxford in zones +25° to +31° for the Astrographic Chart, from 1892 onwards, do not yet allow of this direct method of attack on the

problem; but when compared with the Cambridge observations, if the rotation suggested by Sir David Gill exists, the plates taken early should give different results for the Cambridge 'magnitude-equation' from those taken later. The effective interval available is only about five years (very small), and the effective range of magnitudes about three. But since this implies a difference of $0^{s}\cdot0012 \times 5 \times 3 = 0^{s}\cdot018$, the inquiry is not hopeless, even now.

4. The comparison of a large number of plates gives a quantity about as large as that found by Sir David Gill, *but of the opposite sign.* If this sign is correct the phenomenon cannot be a rotation.

5. Assuming it correct, we can explain the facts by assuming that the stars of the Milky Way are different in size from others, so different that where the Milky Way appears in (say) the N. hemisphere faint stars, which we take to be more remote than brighter ones, may be really nearer. The effect of the sun's motion in space would then no longer be symmetrical about its apex, and the disturbance would have opposite signs in the two hemispheres, since the Milky Way appears in belts of R.A. on opposite sides of the sphere.

4. *A Standard Scale for Telescopic Observations.* *By* PERCIVAL LOWELL.

1. *Present State.*—At present there exists no criterion among astronomers for the weight to be attached to any given observation due to the atmospheric conditions under which it is made. Yet these atmospheric conditions are among the most important factors entering into an astronomic observation. They are far more to the point than the size of the instrument. For our telescopes have long since outstripped the conditions under which they are put to work; the great bar to advance to-day, whether visually, photographically, or spectroscopically, being not instrument but atmosphere. Each man realises this, but marks his own work on his own scale, as if he should take his own foot as the unit of length.

2. *Difficulties of this Condition.*—In consequence no absolute value is assignable to any man's work, and no comparison between different men's work is possible whether in accuracy or credibility. The practical outcome is that the only test is the test of time, and while the world is waiting for confirmation of any new result just so many years are lost.

As important is the incapacity to leave permanent records of observations capable of being compared with newer ones as time rolls on.

3. *A Change necessary.*—A change in this state of things is imperatively needed. It is time a standard scale for observations were introduced similar to what the metric system is, that it may do what that does for physics generally.

4. *Possibility of a Criterion.*—Until lately such a scale has not been feasible owing to ignorance of the conditions upon which it must be based. Studies however directed to that end, first at Arequipa and then at Flagstaff, during the past few years have resulted in the knowledge of the conditions which constitute good or bad seeing, and have thus enabled an absolute scale to be constructed.

5. *The Criterion.*—The basis of the matter lies in the discovery that systems of waves traverse the air, several of these systems being present at once at various levels above the earth's surface. The waves composing any given system are constant in size and differ for the different currents all the way from a fraction of an inch to several feet in length. If the wave be less than the diameter of the object-glass from crest to crest, the image is confused by the unequal refraction from the different phases of the wave. If the wave be longer than this a bodily oscillation of the whole image results. The first is fatal to good definition, the second to accurate micrometric measurement.

It is possible to see these waves by taking out the eye-piece and putting one's eye in the focus of the instrument when the tube is pointed at some sufficiently bright light. It is further possible to measure their effect by careful noting of the character of the spurious disc and rings made by a star and the extent of the swing of the image in the field of view. By combining the amount of confusion with the degree of bodily motion of the resulting image the definition at any time and place can be accurately and absolutely recorded.

The increasing perfection of the optical image of a star testifies to the increasing lack of damaging currents with reference to the object-glass used. It records all the waves below a certain wave-length. Similarly the amount of bodily motion registers all those above that length. The two taken together give account of all the currents independent of the glass.

6. *The Scale.*—It is therefore necessary only to agree upon some size of glass for making the fundamental tests and then to reduce the results to any aperture by relations which will be found set forth in a pamphlet by Mr. Douglas made at this observatory entitled 'Scales of Seeing.'

The most feasible size for comparison purposes seems the 6-inch aperture.

The scale it is proposed to adopt is therefore as follows:—

With a 6-inch glass—

0 Disc and rings confused and enlarged.
2 Disc and rings confused but not enlarged.
4 Disc defined; no evidence of rings.
6 Disc defined; rings broken but traceable.
8 Disc defined; rings complete but moving.
10 Disc defined; rings motionless.

Synchronous determination of the amount of bodily motion of image in seconds of arc.

5. *Expedition for the ascertaining of the best Location of Observatories.*

By PERCIVAL LOWELL.

In order to discover the best place or places for the location of telescopes in the future it is proposed to send observers furnished with similar instruments and identical instructions to all promising parts of the earth's surface.

Two desert-belts girdle the earth in the sub-tropical regions of Capricorn and Cancer, and from the meteorologic conditions there prevailing these belts offer the greatest promise to the astronomer. In the northern hemisphere the belt shows itself first in the Sahara of Africa, then in Arabia, then in the desert of Gobi, and, crossing the Pacific, crops out again in Arizona and Mexico. Of these the two with the greatest height for their plateaux are Arizona and Mexico and the desert of Gobi. In the southern hemisphere we have the veldt of southern Africa, the western part of Australia, and finally the west coast of Peru and Bolivia. Of these the last is the highest and the Transvaal the next.

With regard to these places we have the most systematic series of records from Arizona, the next so from Peru, some slight knowledge of the Sahara, and next to none of any other locality.

Although the desert-belts promise the best, other localities widely different should also be examined. Chief among these perhaps are the islands of the Pacific.

It is desirable, therefore, to send out observers somewhat as follows:

1. To the desert of Gobi.
2. To the veldt of the Transvaal.
3. To the Samoan Islands.

The observations made at these points could then be repeated elsewhere till the earth's surface should be known from an astronomic point of view.

Each observer is to be armed with a 6-inch glass, all the glasses to be made by the same maker (for instance, Alvan Clark & Sons' Corporation), and to report according to the proposed standard scale of 'seeing.'

It is thus important that the said scale should be agreed to by astronomers generally before the various expeditions start.

6. *Spectrograms of Jupiter, Uranus, and Vesta.* *By* PERCIVAL LOWELL.

Both I. and II. (spectrograms of Jupiter) were taken, practically at the same epoch, about two months before opposition, 1902. The spectrum of the planet occupies the centre, the comparison spectrum, iron, lying on both sides.

I. Slit parallel to the polar axis of the planet. The dark lines of the planet's spectrum run straight across, but are all shifted noticeably toward the violet, due to the earth's approaching Jupiter at the time. By measuring this shift it is possible to tell the date of the photograph.

Running lengthwise of the spectrum, and on either side its centre, are two hazy dark bands. These are the dark tropical belts of the planet. This is proved by comparison with II. in which they are absent.

II. Slit parallel to planet's equator. No lengthwise dark bands visible, the slit taking in only the light equatorial region between them.

The lines in this photograph all slant from the lower right-hand side to the upper left-hand side when the violet end is made the top. This is the effect of the planet's rotation and is very evident.

Furthermore, the right side of the planet's spectrum fades off, the left side ending abruptly. This is due to the planet's phase. It being before opposition, the phase was on the side carried away from the earth by the body's rotation. This agrees with the shift in the lines—toward the red on the right. In I., on the other hand, both sides of the spectrum band are nearly alike and both are more definite than the right side of II., less so than the left side of it. This agrees with the known fading out of the planet toward the limb—when full.

III. Spectrogram of Uranus with Saturn for comparison spectrum on either side.

A dark band appears in the spectrum of Uranus in the yellow, which has no counterpart in that of Saturn.

IV. Spectrogram of Vesta with Saturn as comparison spectrum on either hand. Vesta's spectrum has no gaps like that of Uranus.

7. *The Uncertainty of our present Knowledge of the Distance of the Sun.*
By A. R. HINKS.

In 1896 it was resolved to adopt in all the Nautical Almanacs a uniform value 8″·80 for the solar parallax. The four determinations of principal weight were:—

From Gill's heliometer observations of minor planets, 8″·802.
From all determinations of the constant of aberration, 8″·799.
From all determinations of the parallactic inequality of the Moon, 8″·794.
From mass of Earth found from motion of node of Venus, 8″·762.

The evidence was thus three to one in favour of 8″·80.

Since this discussion was completed by Newcomb, the evidence has begun to give way. New determinations of the aberration constant and of the theoretical relation between the parallactic inequality and the solar parallax have agreed in reducing two of the results, so that the evidence now stands—

From Gill's heliometer observations of minor planets, 8″·802.
From constant of aberration of light (Newcomb's latest discussion), 8″·777.
From the parallactic inequality of the moon, less than 8″·773.
From motion of node of Venus, 8″·762.

The evidence is now three to one in favour of a value less than 8″·78. It is therefore peculiarly important to know as soon as possible the result of the observation recently made upon Eros. The author outlined a scheme by which nine days' photographs made and measured at some eight observatories would be reduced at Cambridge, and expressed the hope that by thus limiting, in the first place, the programme of reductions it would be possible to say in two or three years what was the verdict of Eros.

8. *The Positions of Hydrogen and Helium in Relation to the Earth's Atmosphere. By* Professor G. H. BRYAN, *F.R.S.*

SECTION B.—CHEMISTRY.

PRESIDENT OF THE SECTION—Professor EDWARD DIVERS, M.D., F.R.S., V.P.C.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

The Atomic Theory without Hypothesis.

IN opening the Chemical Section of the British Association in this city and in the halls of the Queen's College my first words must be those of reverence for the memory of Thomas Andrews, for so many years the Professor of Chemistry in this College, whose investigations into the properties of gases—above all, those which resulted in the recognition and determination of the critical pressure and temperature of carbonic anhydride—have become a part of the foundation of the Kinetic Theory of Gases. At the Meeting of the British Association here in 1852 Andrews was President of this Section, and again at the Meeting in Edinburgh in 1871.

Since the Meeting last year another distinguished chemist, formerly professor in one of the Queen's Colleges, Maxwell Simpson, has also passed away. He, too, acted as President of this Section—namely, at the Meeting in Dublin in 1878. The work by which Simpson's name will ever be recalled is more especially that upon the synthesis of polybasic organic acids.

One other name must not be left unmentioned in this Address: it is that of a long-time Fellow of the Chemical Society who has been intimately connected with the British Association—I mean that of George Griffith, the genial and most effective Assistant General Secretary of the Association for so many years, who died four months ago. He had visited Belfast in the spring and made the preliminary arrangements with the Local Committee for this Meeting. He joined the Chemical Society in 1859—just one year before I did—and remained a Fellow until his death.

It is now almost a century ago since John Dalton made known to the world his theory of the nature of chemical combination by the publication of a table of atomic weights. He had been occupying himself for some years with the study of the physical properties and atomic constitution of gases before he was led to extend the notion of the atom to chemical phenomena, and thus to form that conception which was to become celebrated as the atomic theory. In his laboratory note-books, preserved from 1802 onwards, the publication and analysis of which we owe to Sir Henry Roscoe and Dr. Harden, no reference is made to the theory till 1803, but we may well believe with Henry that it was already in Dalton's mind just a hundred years ago. But however that may have been, it seems fitting in a year so closely approaching the centennial of its publication as the present that the occupier of this Chair should address his audience on a subject of such general interest and importance as the atomic theory, if indeed there remains anything to be said on a subject which has so long and so fully engaged attention.

I dare not assert that I have found anything actually novel to bring before you with regard to the atomic theory, but I may say that there has certainly long seemed to me to exist the need to treat it as being a true theory instead of as an hypothesis, and to teach it and discuss it accordingly.

In thus setting forth what appears to me to be the proper form of the atomic theory, I shall have, at the risk of overtaxing your patience, to restate and examine most of the fundamental and familiar principles of our science in order to illustrate and justify the view I take. Not only this, but in order as directly and briefly as possible to meet the objection that whatever the atomic theory may be it cannot be introduced to the student of chemical philosophy in another form than that now in use, I shall sometimes have to adopt, in order to show what can be done, a didactic method which, in most other circumstances, would be quite inexcusable before so distinguished an assembly.

The atomic theory of chemistry stands unsurpassed for the way in which it has fulfilled the purpose of every great theory, that of giving intellectual mastery of the phenomena of which it treats. But in the form in which it was enunciated, and still is universally expressed and accepted, it has the defect of resting upon a metaphysical basis, namely, upon the ancient hypothesis that bodies are not continuous in texture, but consist of discrete, ultra-minute particles whose properties, if known, would account for those of the bodies themselves. Hence it has happened that, despite the light it throws upon the relations of chemical phenomena and the simple means it affords of expressing these relations, this theory has always been regarded with misgiving, and failed to achieve that explicit recognition which its abounding merit calls for. Indeed, the desire has been expressed to see the time when something on a more solid foundation shall have taken its place.

Now, it is not my intention to discuss the merits or demerits of the atomic hypothesis, which can indeed no longer be treated as a merely metaphysical speculation. What I would do to-day is to impress upon you that, in spite of all that has been said and written about the atomic hypothesis in connection with chemistry, the atomic theory propounded by Dalton and adopted, implicitly at least, by all chemists, is not founded upon the metaphysical conception of material discontinuity, and is not explained or illuminated by it. For if that should be the case there will no longer exist any grounds for hesitation in accepting the theory quite explicitly, and then the anomalous condition of things will be removed of a theory being in universal use without its truth being freely and openly admitted. For the sake of clearness, it is convenient to restrict the term 'atomic hypothesis' to the old metaphysical view of the discontinuity of matter whilst applying the term 'atomic theory' to the current elaborated form of the Daltonian theory; this distinction is adhered to in the present Address.

In the peroration to his admirable discourse upon atomic weights or masses delivered before the Chemical Society in 1892 as the Stas Memorial Lecture Professor Mallet, F.R.S., said: 'By the chemist at his balance the arm of reason is directed into those regions of almost inconceivable minuteness, which lie as far beyond the reach of the most powerful microscope as that carries us beyond the reach of the naked eye, quite as impressively as that same arm is stretched forth by the astronomer at his divided circle to reach and to weigh the mighty planets that shine in the remotest regions of our solar system.' On two occasions I have heard the same comparison between the chemist and the astronomer made by Lord Kelvin when he was in the company of chemists; and undoubtedly both these high authorities have only then expressed the general view as to the nature of the domain of the chemist. Yet I venture to question whether there is anything in the ways and work of the chemist to support such a view and give point to Mallet and Kelvin's comparison. If, indeed, chemistry is a science which rests upon the atomic hypothesis and, therefore, would cease to exist in the form into which it has developed, should matter prove to be continuous and not discrete, nothing can be said against the view that it is a science of the minute. But I am sure there can be no one ready to maintain that, if the hypothesis of the atomic constitution of substances were an unfounded one, the atomic theory would have been a discovery of no great importance; and Dalton himself, instead of being the founder of the chemistry of to-day, have been little more than the discoverer of the law of multiple proportions. If that cannot be maintained, what, then, becomes of this conception of chemistry as dealing with the minute? So far as comparison can be made between the operations of the astronomer and the chemist, it is the former and not the latter who, as a matter of fact, deals with the almost infinitely minute. For if, indeed, the chemist often works upon comparatively small amounts of substances, and, consequently, with very sensitive balances, that is, as we all know, only for reasons of economy of time, materials, and apparatus; otherwise he works on the largest possible scale, with the object of attaining to the highest degree of accuracy and perfection. The astronomer, on the other hand, has, perforce, to deal with the smallest visible things in nature, the nearest approach there is to geometrical points, those fixed points of light in the heavens which are only known through scientific investigation to be other than what they seem to be. It is, therefore, only as interpreted by the atomic hypothesis that chemistry can be said to deal with the minute.

When the atomic theory is expounded in the usual way it is commonly and correctly stated that, on the assumption that substances consist of minute indivisible particles having weights or masses bearing the ratios of the combining numbers assigned to them, the laws of chemical combination by weight necessarily follow, and are thereby explained. But then the converse is not true—that because chemical combination obeys the well-known laws, substances consist of discrete particles. Nor does the assumption of the truth of the atomic hypothesis afford any real explanation of the facts expressed by the laws of chemical combination, or more comprehensively by the atomic theory, when that theory is given in non-hypothetical terms. It is just as difficult to see why the atoms should possess the weights on chemical grounds assigned to them, as to see why substances interact in the proportions that they do; that they do do so is, in either case, an ultimate fact, for which no explanation has presented itself. The atomic hypothesis masks this ignorance and deadens inquisitiveness. Notwithstanding all this, which is incontrovertible, it is certainly a common opinion that in chemistry we investigate the minute and intimate constitution of things.

But if, after all, chemistry does not deal with the minute. or, rather, if it has no concern with the magnitude of single bodies or their molecules; if the atomic hypothesis is not the foundation of, or necessary to, the atomic theory, then it is certainly most desirable and important that the theory of chemistry, which, with all its modern developments, I take to be indisputably the atomic theory of Dalton, should be held and expounded without any reference to the physical constitution of matter, in so far as that remains unknown. The opinion that chemical theory should be developed without reference to the atomic hypothesis has indeed all along been held by many eminent chemists; but then the dilemma appears to have presented itself to them, that either the atomic hypothesis must be granted, or the atomic theory must be dispensed with, since it falls with the hypothesis. That dilemma I do not recognise, and the practice of chemists shows beyond doubt that it is always ignored. Investigators use the theory, whether they admit it or not; teachers of the science find it indispensable to their task, however much they may deprecate, and rightly so, unreserved acceptance of the atomic hypothesis as true.

Refusing to commit themselves to belief in the hypothesis, chemists have thought from the first to escape the adoption of the atomic theory by putting Dalton's discovery into something like these words: Numbers, called proportional or combining numbers, can be assigned to the chemical elements—one to each—which will express all the ratios of the weights or masses in which substances interact and combine together. Perhaps the atomic theory is here successfully set aside by expressing what is an actuality as an unaccounted-for possibility. But then those who use any such mode of expressing the facts, without reference to the theory, never fail also to adopt the doctrine of equivalents, and thus, by this double act, implicitly give in their adherence to the theory.

Divested of all reference to the physical constitution of matter, the atomic theory is that the quantities of substances which interact in single chemical changes are equal to one another,—as truly equal in one way as equal masses are in another,—

and, therefore, that chemical interaction is a measure of quantity of unlike substances, distinct from and independent of dynamical or mass measurement.

Dalton, indeed, did not express himself in any such terms, his mind being fully possessed with the ancient and current belief upon which he framed his theory that substances are made up of minute, discrete particles. But it is clear enough that his theory was that of the existence of another order of equality between substances than that of weight. Up to his time, the weight or mass of every ultimate particle of any substance whatever appears to have been assumed to be the same, the atoms being alike in every way. That assumption is still made by many thinkers, chemists among them; we meet it, for example, in the different forms of the hypothesis that the elements are all, in some way, physically compounded of a universal and only true element, as in Prout's hypothesis. Dalton saw things differently, and recognised that, on the assumption of substances being constituted of particles which never subdivide, weight or mass cannot be the same for every such particle, except in the case of those of any one simple substance. Therefore, having given some numbers showing what he believed to be the respective weights of the atoms of several simple substances, taking that of hydrogen as of unit-weight, he proceeded at once to invent symbols for these atoms to indicate, not only their distinctness in kind, but above all things their indivisibility and their equality, properties which the use of their atomic numbers would have inadvertently concealed or even apparently denied, and could never have expressed or connoted.

It was only in this immediate invention and use of chemical symbols that Dalton's conception found clear expression; and again it is by the universal adoption of such symbols that chemists have shown their real acceptance of the atomic theory, even while displaying, not infrequently, their scepticism as to its truth. The replacement by Berzelius of Dalton's marked circles for atomic symbols by letters which should recall the names of the substances was in a way a great improvement, but it has had the serious consequence of causing chemical symbols to be usually first brought under notice merely as serviceable abbreviations for the names of the elements, and only then described as representing their atomic quantities. Now, evidently, what the character used as symbol shall be is, theoretically considered, but a petty detail; the vital point is what the character symbolises, and that is the atom. It does not symbolise the name; it only indicates that and recalls it. It may be said indeed to represent the atomic number, since it stands in place of it; but it is made to do so only in order that we may for the time forget this number and have in mind the integral character of the atom. It is not the 4006 parts of sodium hydroxide and 8097 parts of hydrobromic acid, or approximately twice as much of the latter as of the former; it is not these gravimetrically expressed interacting quantities that we are to think of when the formulæ $NaOH$ and HBr are before us, as we too often strive to do; it is not these, from a chemical point of view, meaningless numbers of parts, but quantities which are equal in the sense of chemistry, that are expressed as such by these symbolic formulæ. The real purpose of chemical formulation is not to abbreviate or replace language, but to facilitate, if not ensure, abstraction from and non-contemplation of gravimetric numbers.

I have just passed from atomic symbols to the formulæ of molecules; but this was not without warrant. In the form in which I have enunciated the atomic theory, it relates to the chemical interaction of substances, whether compound or simple, and the equality of the quantities concerned is the equality of molecules, since these are the quantities of substances entering into or coming out from single chemical interactions. Were it not, therefore, for fear of confounding it with the mechanical theory of that name, the atomic theory should be called the molecular theory of chemistry. It might, indeed, have happened to be so called by its author, for Dalton has told us that he had in mind both atom and molecule as names for his chemically ultimate particles, and chose the former because it carried with it the notion of indivisibility. He extended also, as we do, the use of the term 'atom' to chemically compound substances, since their combining quantities are chemically indivisible.

Next, I would point out that in the atomic theory the notions of indivisibility and equality are inseparably involved. The indivisibility of atom and molecule is not absolute or ultimate, and Dalton distinctly guarded himself against being understood to claim for the atom more than chemical indivisibility, and chemists of to-day assert no more than this. This indivisibility being conditioned by the equality of molecules, the importance of emphasising it rests only upon the danger, when it is overlooked, of losing sight also of the chemical equality through the gravimetric inequality receiving numerical expression, and thereby conveying the notion of divisibility, though only gravimetrically. The idea of indivisibility in connection with the atom or molecule is intrinsically quite subordinate to that of equality; for equality, being unity or oneness brought into relation with itself, the conception of it carries with it and includes that of indivisibility. Any rational hypothesis as to substances consisting of ultimate particles will include the notion of their being indivisible particles; and the import of the hypothesis in chemical theory must lie, therefore, not in this indivisibility, but in the nature of the equality of the particles. By his atomic theory Dalton asserted that where the substances are different this equality is chemical instead of gravimetric.

Molecules are equal in the sense that they are quantities of their substances which are interdependent and coordinate in any and every single chemical change in which they take part together. It is a form of equality for which no close parallel can be found; but as to that it should be remembered that this equality relates to the phenomena of the tranformations of substances into each other, which, though they form so large a part of the phenomena of the universe, are fundamentally distinct in nature from the rest of the behaviour of bodies throughout which the substance remains what it was. In some agreement with it there is that of mechanical pressures when these balance or neutralise each other, and therefore are opposite and mutually destructive though equal. But such pressures when exerted in the same direction are also equal in their effect on any body in their path, whereas in chemical interactions the effects of molecules or equal quantities of two unlike substances are only equal in the sense that each is that quantity which interacts with the same quantity of some third substance, which itself proves to be also a chemically equal quantity to them. For the products of the interaction in the one case are in part at least not the same as those in the other, though all prove chemically equal in further interactions.

To give an example: the molecule of ammonia is equal to that of aldehyde in that it combines with it and with it disappears, or ceases to exist as such. For the same reason it is equal to the molecule of hydrocyanic acid, and molecules of aldehyde and hydrocyanic acid equal to each other, because they, too, combine and disappear as such in doing so. But the molecule of ammonia again equals that of aldehyde in effecting transformation of hydrocyanic acid and its own self into something else. And lastly, chemically equal or molecular are the products of these combinations; aldehyde ammonia, ammonium cyanide, and aldehyde-cyanhydrine, not only among themselves, but also with the quantities of ammonia, aldehyde, and hydrocyanic acid from which they come and into which they return in other chemical changes. But with all this quantitative equality in transforming power, the substances produced are unlike and, each to each, peculiar to one of the three acts of chemical combination; and on this account exception may be taken to the treatment of molecules as equal chemical quantities. Yet the equality of molecules here asserted is but an extension of what is meant by the equivalence of certain atoms and radicals, since the atom and the radical are, nowadays, conceptions entirely dependent upon and derived from that of the molecule (apart, of course, from the atomic hypothesis); and this universally allowed equivalence admittedly does not extend to the identity of the products of the replacing activity of the atoms and radicals.

Quantitative equality and equivalency, it is true, have not the same meaning, equivalence being used to denote qualified equality, equality in certain specified ways, of quantities not equal in all other ways and possibly in no other. Quantities of different substances cannot, strictly speaking, ever be equal, and can only be styled so in the sense of being equivalent; for were they equal in every way the substances would obviously be the same. But this fact, if it ever strikes one, is ignored by universal custom, and quantities of substances, however unlike—feathers, air, water, salt, and what not—are taken to be all equal, even by chemists as by the world at large, if only they have the same weight, notwithstanding the incongruities of the substances. I proceed now to show the baselessness of this conviction, but only to bring out more strongly the claim of chemical activity to equal rights with weight or mass in determining what are equal quantities of substances, for I am aware that here I have nothing to tell you that you do not already know. Weight being only the gravitational measure of mass, which itself is independent of it, quantities of substances are held to be equal when their masses are equal. Now, mass is quantity of matter. But what then is meant by matter? The answer must be either that it is a general term for any and all substances, or else that it is the common basis of all substances, which presents itself in all the different forms which are known to us as such, by virtue of a corresponding variety in its intestinal motions. I gladly pass over the latter answer without discussing it, on the ground that it introduces the subject of the intimate constitution of substances, which it is my set purpose to keep independent of in this discourse. I will only say of it that it would probably be the answer of many physicists and chemists, and yet that it gives such a limitation to the nature of matter as makes the common expression 'constitution of matter' devoid of all meaning. That expression means, and can only mean, the constitution of substances in common; and this brings me to the first answer, that matter is the term standing for all substances in common. Now, one thing which all substances possess in common is the property of resisting pressures; pressures not only of moving bodies, but of the motions of the ether and electrons. Measured or quantified, resistance becomes mass, all that can be signified by this term being the quantity of the resistance or inertia a substance exhibits when tested. It is the measure of a property of the substance, that is all; and there is no other way of quantifying a substance than through some one of its properties. No quantities of different substances can, as such, be commensurable throughout; and when compared and measured through some common property, such as the possession of mass, the equivalence or pseudo-equality found by this means is not the same as that found when some other common property is taken as the means of measurement. But experience has shown that though there are several rational and comprehensive ways of instituting, through some common property, comparisons between quantities of different substances, they all, with the exception of that of weighing, agree more or less exactly in pointing to the same order of equivalence, that of chemical activity; for with this are colligated those of gaseous volume and the other well-known physical activities, which give nearly the same quantities as it gives of different substances as being molecularly equivalent. There are, therefore, essentially only two measures of quantitative equivalency or pseudo-equality between substances, the dynamical and the chemical or molecular, the one wholly independent of and the other wholly dependent upon the particular nature of the substances compared. The former is the measure of dynamical phenomena, those of changes of bodies, due to their impacts and pressures, which may lead to their deformation and disruption, but do not involve transformations of the substances of the bodies into others; the latter is the measure of chemical phenomena, those of changes of bodies induced by such of their interactions as do involve transformations of the substances of the interacting bodies into other substances. Since it is already settled for us by custom that quantities of different substances are to be called equal when or because they are equivalent gravimetrically, and as it is not to be supposed that we shall ever give up calling 16 kilos of oxygen, of salt, of chalk, and of every other substance, however unlike, equal quantities of them from the gravimetric point of view, we have no choice but also to call molecular quantities of these substances equal from the chemical point of view, if the claim to coordination in equality of chemical with gravimetric equivalency is to be asserted and maintained.

The contention that chemical equality must be regarded as of as clearly defined a nature as gravimetric equality becomes the more weighty when it is reflected that our very definite views concerning gravimetric equality are due solely to the law of conservation of mass, the evidence for and against which, I may remind you, is just now to be discussed by Lord Rayleigh before the Physical Section. The mass of one pound of sodium remains unchanged when the metal is converted into salt, washing soda, or borax; if this were not the case, gravimetric equality would be just as definite as it is now but physicists would have to argue for its general recognition in much the same way as I am doing now for the recognition of chemical equality.

In further justification of this claim of chemical equality to coordinate rank with dynamical equality in the quantification of substances it may be well to take the fact into consideration that the determination of the former is independent of that of the latter. Overlooking the difficulties of the task, let there be at hand or always procurable unlimited numbers of parcels of the different substances to be experimented upon, each of which, by other means than weighing, such as spatial measurement, can be known to be equal to, or greater or less than, other parcels of the same substances. Suppose, now, that after many trials, one of a number of equal portions of sodium hydroxide has been found to be the quantity just necessary to interact with one of a number of portions of hydrochloric acid also equal among themselves. The products of the interaction will be some water and some salt. We can now have placed before us a parcel of sodium hydroxide equal to that previously used, another of hydrochloric acid also equal to that used, and the water and the salt obtained, and then have before us chemically equal quantities of four substances. Let now, by spatial measurement, a number of parcels of water be portioned out, all equal to that of the water obtained, and a number of parcels of salt equal to that of the salt obtained. By a series of trials we find a quantity of silver nitrate just sufficient to interact with the sodium chloride, and having, by supposition, taken this quantity of silver nitrate from a lot of other parcels equal to it, we find that one of these is just sufficient to interact with one of the portions of hydrochloric acid equal to that used in producing one of the portions of salt. Further, we find that the salt and the hydrochloric acid each produce a substance which is the same, namely, silver chloride, and in the same quantity as the other. Along with it in the case of the salt, is sodium nitrate, and in the case of the hydrochloric acid, nitric acid. We can then find that this quantity of nitric acid is just enough to interact with one of those of sodium hydroxide, and thereby produce quantities of sodium nitrate and water, respectively equal to those obtained in the other interactions. If now we conjoin with these experiments others in which hydrogen, sodium, and silver are each caused to combine with chlorine, and others in which hydrochloric acid, silver chloride, and sodium chloride are electrolysed into these elementary substances, evidence is obtained of such facts of chemical composition and decomposition and of double decomposition (or what happens when compounds interact) as those upon which the science of chemistry is framed.

In teaching chemistry the point is kept too much in the background, if not altogether out of sight, that the chemical equality of quantities of different substances is independent of all other relations of equality between them, and that, therefore, its validity is not affected by the fact of its terms agreeing with some and not with other terms of equalities determined in other ways. Instead of bringing out this point the molecule of water is given out as being, primarily and prominently, that quantity which has eighteen units of mass and which measures two unit volumes. Both statements happen in the nature of things to be true, but neither of them describes the molecule. Let it be clearly understood from illustrative examples what is meant by 'chemically equal,' and there is hardly more to be said as to what constitutes a molecule of water than that it is the quantity of it chemically equal to that of some other substance presenting itself for comparison. 'Molecule' is a term of relation: it stands for an equal quantity, not for any particular quantity; but as such it is as easy to understand and as indefinable as an equal volume or an equal weight of a substance.

It is then only as colligated equalities, established by experiment, that gaseous volumes, osmotic pressures, and other properties of substances come into consideration, first as enforcing the truth of the conception of the indicated quantities as equal, and then as the means of molecular measurement without resort to chemical change. But of the purposes served by the colligative properties, that of giving molecular measurements without recourse to the evidence afforded by chemical change is well known to be of the very widest application. To determine chemically the molecular equalities of substances, single chemical changes of suitable character, changes which are cases of double decomposition, have to be looked for; and to know these with the desirable degree of certainty calls for a much larger acquaintance with the chemical behaviour of the substances than can usually be gained at the early stage of work when the knowledge of the molecule is of the utmost assistance in the further investigation of the nature of the substances. Consequently, it is nearly always through recourse to physical methods that the molecule is first ascertained, and then through the molecule the certainty acquired that some particular interaction is a single one, thus reversing the normal order of things, which undoubtedly is that the molecule in chemistry, however it may have been first determined, is recognised as such by being what it is in chemical change.

I shall have been wholly misunderstood by you if you suppose that I would make light of the importance of the balance in chemical operations, or of the value of its indications in chemical investigations. Once the weights of molecular or atomic quantities have been ascertained the balance becomes the most accurate and generally the most easily applied instrument for apportioning substances in these quantities. Chemical interaction, to be employed in this way and without the aid of the balance, is practically useless, for the reason that it involves the destruction of the quantities it measures. Out of this dependence on the balance arises the exceeding importance of accurate tables of atomic weights, from which molecular weights are derived by addition; but the place for these tables is not on the walls of the lecture-theatre, but in the laboratory pocket-book and, perhaps, in the balance-room. Besides the use of the balance and of atomic weight tables for getting and calculating out molecules of different substances at pleasure, there is the indispensable service they perform in enabling chemical analysis to be carried out and applied to the solution of the problems offered by chemical change. The primary problem of every science is to find some element of sameness in the diversity of its phenomena, in order that they may be compared, a problem which was solved for chemistry to a large extent by Dalton, and ceased to exist when the distinction had been made between molecule and atom. But this having been solved, there comes the other problem, namely, to find definite, that is, quantitative differences in the midst of the uniformities, and these for the chemist are differences of mass or weight. Through that redistribution of mass which attends chemical interactions it has been possible to trace out to some extent the nature of the transformation of substances and develop the science on the lines of chemical composition and chemical constitution. Thus, then, the balance has become and will continue to be the necessary instrument of chemical research; but again I would remind you that it records its facts in units which are not ours, and of which we avail ourselves only as the means to an end. Sodium chloride is chemically composed, not of 3545 equal parts of chlorine with 2305 of the same equal parts of sodium, but of equal quantities of these simple substances.

The theory of chemical molecules or equalities and their relations to the equalities between the weights and gaseous volumes of different substances were brought to light not by Richter's law of chemical combining proportions, and not by Avogadro's hypothesis as to there being equal numbers of particles in the same volume of different gases, but in the first place by Dalton's atomic theory and Gay-Lussac's law of simply related gaseous volumes in chemical change; and then, much more fully in the middle of the last century, through the brilliant work of Gerhardt, Williamson, Laurent, Odling, Wurtz, and others, in the purely chemical field. Dalton gave us the conception of the molecule, though confused with that of the atom, as the unit of measure of chemical activity in place of the gravimetric unit; the work of the chemists of the last mid-century gave us a fuller conception of the molecule, along with the notion of chemical change as being substitution in the molecule effected by what became known as double decomposition. Up to that time chemistry had been treated only as the science of compounding and decompounding or reducing. Sodium added to oxygen gives soda, sulphur added to oxygen gives sulphuric anhydride, soda added to the anhydride gives sodium sulphate, ethylene added to chlorine gives dichlorethane, water subtracted from alcohol leaves ether, and so forth. All this is strictly true in a limited way, but then it is not chemistry; and the addition precedes and does not constitute the chemical union. In the sodium sulphate we perceive no soda, no anhydride, no sodium, sulphur, or oxygen. That is to say, there is evidence of the addition and subtraction of mass and some other such evidence; but, for the rest, evidence of addition there is none. Were it otherwise there could be no chemistry. It is true that one of the great things accomplished by chemistry has been that of establishing the law of the conservation of mass, without which to rely upon the chemist would be unable to carry on his experimental investigations. But that is only because, like the steady point to the seismologist, it is there unchangeable when all else is changing. Since it is the law of no change, it cannot serve to explain what is change. Far from being the science of the composition of substances, chemistry might be defined as being the science of the non-composition of substances where that composition might have been looked for from the antecedents. If salt is verily a compound of sodium and chlorine, and can be broken up into these, why have the fragments not the marks on them of that whole of which they formed a part? It is true that 5850 parts of salt become 3545 parts of chlorine and 2305 parts of sodium, nothing being gained or lost in weight; but to account for that there is no need of chemistry, a science which takes cognisance of the phenomena of change, and not of those of unchanged properties. The use of the word 'composition' in chemistry cannot be discarded now, and all that is necessary to make it unobjectionable is to see that the term is always qualified by the prefix 'chemical' when there is a possibility of mistake about its significance, and that that significance is carefully explained, if not defined and fully illustrated, before it is given over to the beginner.

The facts of a chemical nature about common salt which cause the statement to be made that it is a chemical compound of chlorine and sodium are such as these. Salt can be wholly changed into sodium and chlorine; these substances brought together change into salt and nothing else; salt and sodium, each under conditions appropriate to it, change into the same substance, called also a sodium compound, such as sodium hydroxide; salt and chlorine, each in its own way, change into the same chlorine compound, such as hydrochloric acid; neither sodium nor chlorine, one apart from the other or the other's chemical compounds, ever changes into salt; salt is, directly or indirectly, producible in the chemical interaction of a sodium compound with a chlorine compound; the properties of salt are much less like those of either sodium or chlorine than like those of some other substances; in sensible and other physical properties the chemically compound substance, salt, is as simple as or simpler than either of the chemically simple substances, sodium and chlorine; lastly, the laws of combining proportion by weight are obeyed in all the chemical changes in which salt takes part.

With exclusive reference to such facts as these, the chemical composition of a substance will, I think, be found to be satisfactorily defined, as its having the power, capacity, or property of being wholly producible from and wholly convertible into, directly or indirectly, those substances of which it is said to be composed. A simple substance differs from one that is compound only in not possessing the power of being by itself convertible into two others, or of being produced alone from any two others. Simple substances are not less varied or less complex in their physical properties than compound substances, while their chemical constitution is often more problematic than that of many which are compound. The term 'simple,' therefore, is as misleading in the language of chemistry as 'compound,' unless defined and qualified in use by the word 'chemically.'

The ground really occupied by chemical composition in theoretical chemistry is now greatly limited; for with the full acceptance of the idea of the molecule and of the atom as a derivative of it, its place has been taken by chemical constitution to an extent hardly realised. The useful and practically necessary expression of the results of the quantitative analysis of a new substance gravimetrically is all that can strictly receive the name of its chemical composition. When the term is applied more widely it is used for what are really the simpler forms of chemical constitution. It was otherwise before the conception of the molecule had become current and the atom had become a derived function of the molecule. Chemical composition as expressed by Dalton in atoms is indeed that and nothing else. Carbonic anhydride is composed, according to him, of two atoms of oxygen to one of carbon, as against carbonic oxide which is composed of one; marsh gas of two atoms of hydrogen to one of carbon, as against olefiant gas composed of one. But then it was only numerical necessity which led him to adopt such a mode of expressing the facts. The same necessity, it is true, affects us also in the matter of carbon dioxide, of water, and of ammonia, but how little it does so is shown by the many cases in which the empirical or simple composition is expressed in multiples. The atomic chemical composition of ethylene is two of hydrogen to one of carbon, and that of benzene one of hydrogen to one of carbon. When we say, as we always do, that the one substance is 'composed' of four atoms of hydrogen to two of carbon, and the other of six of hydrogen to six of carbon, we give what is information concerning the constitution of these substances. Call it the composition of the molecule as we may, it is evident that by composition we can here mean only constitution. As with polymerism, so with isomerism, and in a more marked way. Mercurous sulphate and mercuric oxysulphite, quite distinct salts, have yet the same composition.

In the great reformation wrought by the chemists to whom I have referred, but by Gerhardt in particular, the new light set up in chemistry was the notion of what came to be called 'double decomposition' in chemical change. The phrase is not, perhaps, happily constructed, but it has the merit of needing some explanation of its meaning before it can be understood, and troubles, therefore, through a too simple apprehension of the sense of the word 'composition' are hardly to be feared. Its introduction into chemistry marked the ascendency of the idea of the molecule as the factor in chemical change whose interactions with other molecules were to be considered, instead of those additions which, as chemical phenomena, never take place. It led also to new conceptions of the nature of the atom and the compound radical as being the quantitative and qualitative expressions of the powers possessed by substances to change into others, and to the conception of the valency of atoms and radicals as expressing the nature of the connection of successive chemical changes. The zeal with which it was attempted to force all chemical changes into the form of double decomposition interfered, perhaps, with the full recognition of its importance; but the fact remains that, with hardly an exception, all that is stated concerning the nature of those chemical changes in which two or three substances become one, or one becomes two or more, is based upon notions derived from the study of double decomposition.

The fundamental value of double decomposition consists in its displaying threads running through chemical transformations which can be followed up. When two substances change into two others, and only then, there can be found, in most cases relations of resemblance, both physical and chemical, between the before and after of a chemical change. Instead of the striking unlikenesses shown by the substances formed by quasi-addition to those from which they are formed, there are here met with the similarities of the outcoming to the interacting substances, and the similarities between the products of different interactions in which the acting substances are similar. Chemists had been for very long familiar with acids, bases, salts, without becoming deeply impressed with the significance of the resemblances which these class-names imply, and also with the facts that acids beget acids, bases bases, and salts salts, or in more general terms, that substances in interaction produce others like them, and that differences between the products and the agents in one change are distinctly repeated in a similar change in which other substances are concerned, points now given expression to by such terms as 'chemical constitution,' 'homologous' and 'analogous series,' 'Kopp's law,' &c.

What is so important to consider in the study of double decomposition is that the fact, that the sum of the masses of the two products of the change is the sum of the masses of the two interacting substances, presents itself no longer as being merely the evidence of the massing together of substances into a compound; for there is in double decomposition to be considered that redistribution of mass which, on the one hand, is found to correspond to and be part of a general though not sharply defined redistribution of physical and chemical properties; and, on the other hand, to be obviously irreducible to that interchange of those simpler substances which in many cases are produced in the simple decomposition of the acting substances.

The physical properties of substances, or rather their sensible qualities, are of too uncertain a character for their redistribution to be safely traced. But it generally does result, amongst inorganic substances, at least, that colour is transmitted, the saline, acid, bitter, or other taste of one of the active substances will appear, with more or less distinctness, in one of the products, a relatively volatile and a relatively fixed substance together will yield a similar pair of products, a dense and a light substance will yield a dense and a light substance, and so on. The chemical properties, however, are quite definitely redistributed to a large extent, a fact sufficiently illustrated by saying that an iron salt yields an iron salt, and a sulphate yields a sulphate.

But this is not a redistribution in which simpler substances, or indeed any other substances than those interacting, play a part: as soon becomes evident on attempting to establish the contrary by an appeal to the facts. While silver acetate and silver sulphate resemble each other and also silver nitrate as silver salts, they do not resemble silver itself; and though silver nitrate resembles sodium nitrate as nitrate, there is not even a substance known which is related to these salts as silver is related to silver salts. It might be objected to this that there may yet become known such a substance, which in its ultimate decomposition would give one molecule of nitrogen to three molecules of oxygen. If instead of nitrate were given acetate or cyanide, there would be found in the substances acetic peroxide and cyanogen, it might be said, the analogues of the as yet unknown substance of the nitrate. But the point I would make is that nitrate, sulphate, &c., are names with well-defined meanings independent of the fact that the corresponding substances are not known; for it follows without argument that also the terms silver, iron, chloride, &c., should be equally independent in meaning of the existence of the substances silver, sodium, chlorine, &c. It is a familiar historical fact that cæsium, helium, and fluorine were chemical names long before the substances cæsium, helium, and fluorine became known. We might well be convinced, therefore, without going further, that constitutional names, names which convey the facts of likenesses preserved in chemical change, cannot be indicators of the presence of the substances for which they may be also used. For, that being the case, we have no grounds for assuming that silver nitrate in interaction with sodium sulphate decomposes into the substance silver, which then combines to form silver sulphate. But fuller proof than any appearance of likeness or unlikeness can give is afforded by facts which became known and appreciated in connection with the chemical molecule. Typical of them all is the fact that in none of its interactions does chlormethane yield a hydrocarbon simpler than methane or than itself. Under those conditions in which it might have been expected to give a substance which would be methyl, it produces ethane, a substance which chlorine converts into another substance, having instead of one-third only one-sixth less hydrogen in its composition. Similar results have been obtained in all cases where the point can be determined—that is, where the simpler substance looked for would still be a compound substance, and such simpler derivatives are looked for no longer. The monohydride of oxygen or sulphur, the dihydride of nitrogen or phosphorus or arsenic, the mononitride of carbon, the organic compounds, methyl, phenyl, acetyl, are not only unknown, but are held to be nonexistent substances, though their chemical compounds, the hydroxides, amides, cyanides, and the rest, are both numerous and well defined. Whatever other view we shall have to take of the constitution of Gomberg's remarkable 'triphenylmethyl,' it will certainly not be that it is identical with the radical of the triphenylchlormethane from which it is derived, unless we are prepared to allow that carbon is sometimes tervalent. Ethylene the substance differs from ethylene the radical in having its two carbons differently related; but it is difficult to see how to make a similar distinction in the case of Gomberg's substance.

In those other cases in which the point is not strictly determinable, only because the resulting substances are the simple substances themselves, it required but the recognition of molecular quantities to make it evident that these cases run parallel with the others. For, in all changes which can be satisfactorily followed out, the resulting or entering quantity of the simple substance is twice as great as that which can have come from, or gone to form the molecule of either of the compound substances. But if, so far as can be traced, a simple substance comes only half from one molecule of any of its compounds, none of these compounds can contain or be composed of simple substances. All simple substances, therefore, as well as all compound substances, enter into and come out from chemical changes as dual in all of them in origin and disappearance. Their colligative properties have been appealed to in order to confirm this observation, but with conflicting results, sometimes confirmatory of the chemical evidence, sometimes contradictory of it, and sometimes too complex for confident chemical interpretation.

I refer here more especially to Avogadro's proposition, which is in effect that equal volumes of gases are chemically equal or molecular. As in the case of Dalton's atomic theory, there is to be distinguished in this proposition what Avogadro really put forward as new from what he took for granted. Admitting, as was to him a matter of course, that gases have in equal volumes equal numbers of particles, he asserted that in the case of elementary substances these particles are not the atomic particles, but, as in the case of compound substances, particles compounded of these, which interact with the particles of other gases as chemically equal each to each. If now this proposition is divested of all hypothesis, all reference to the mechanical structure of gases, it becomes the law that equal volumes of gases at the same temperature and pressure, whether simple or compound, are almost exactly chemically equal quantities, and once in possession of this law we find nothing becomes clearer by assuming that equal volumes of different gases contain the same number of chemically equal particles. This law is, obviously, an advance upon Gay-Lussac's law similar to that of the chemical molecular theory upon the atomic theory of Dalton. Unfortunately, however, it does not hold good in the case of not a few simple substances, and it seems impossible from the chemical point of view, and consistently with the molecular theory, to admit that, because the gas-volume has only half the expected mass, the chemical molecule of sodium or mercury is not bipartite like that of hydrogen or oxygen, and chemically equal to either.

The dual constitution or chemically compound nature of the simple substances as thus established by the part they take in chemical interactions furnishes further evidence of the untenability of the belief that the molecule is chemically composed of two substances, or their substitutes, simpler than itself, when we consider that, were this true, there would be chemical union between two things perfectly alike, two portions of the same thing. This difficulty was, I believe, first raised by Berzelius, and has never been met. Physically, the matter is simple enough, if motion in the opposite direction is not counted as a difference betwen two masses. But this would be a non-elective union, whilst chemical union is elective.

The difficulty, insurmountable when made, does not arise when the fact is recognised that every chemically single substance, whether simple or compound, is, as a substance, one and without parts, and can never, therefore, be built up of or broken down into parts different from itself. One substance (as two molecules) or two substances change into two others or into two molecules of one, in an interaction which is instant, uninterrupted, and irresolvable into stages, where the interaction is single in character. But just as a body can be mentally analysed as in the investigations of dynamics) into mass and motion, which apart are unknown, and as these again can each be conceived of as further divided, resolved, condensed, and otherwise qualified as centres of mass, compounded motions, and so forth, so the chemist is enabled mentally to find quantitatively defined this, that, and the other mark of the many chemical interactions which have or may have gone to bring it into existence, and will or may again have place in the possible forms of its dissolution into others. The two methyls in the constitution of ethane, about which we are quite certain, are not two things held together till some interaction sunders them in the chemical dissolution of ethane, but the double mark of similarity between it and other methyl compounds in their chemical interactions. We cannot say that only one part of the ethane is methyl, or hydrogen, or carbon, but that part of its nature, of its constitution, is its behaviour as a methyl compound, or, again, as an ethyl compound; or, more comprehensively but less specifically, part of its constitution is its behaviour as a hydrocarbon, as a hydrogen and as a carbon compound. But these are different aspects of it, different relations of it, not differing parts of the one homogeneous substance.

With the laudable object of combating the prevalent notion that matter is something which is the basis or essence of a body, something acting as the medium of the manifestation of its forms of energy, a distinguished and most lucid writer on chemistry has, adequately perhaps for that object, represented a body as a compound of the various forms of energy subsisting together and cohering in certain proportions within the volume of the body. But this presentation of a subject as a cohesion or association of forms of energy is on the same footing as the presentation of ethane as consisting of two methyls bonded together, or two portions of carbon with six of hydrogen. It is compounding what cannot be had apart, what cannot be even conceived of as separate, so far as bodies are concerned. The analysis of bodies into manifestations of different properties are only mental operations. A moving body, a hot body, a green body, an explosive body, becomes by legitimate abstraction a phenomenon of motion, of heat, of colour, or of light, or a chemical phenomenon as our needs require; but the body is there all the while, and its undivided and continuous existence is indispensable to the phenomenon. The body can be hotter or colder, but not that only,—not that without other differences; red-hot iron is throughout a very different thing from cold iron, and ice differs widely from steam in most of its properties. A substance is no more composed of its properties or energies than it is composed of its so-called elements. It manifests its presence in a thousand and one ways more or less distinguishable; its properties are so to manifest itself. But no divisibility of itself while it remains itself can be thought of, no differentiation can be suggested, no nucleus with its superinduced properties can be traced.

It ought, therefore, to be possible to express all the particulars of chemical constitution without making any assumption as to substances having parts or structure. Of chemical constitution itself, I doubt whether there is to be found a definition which is not couched in language having reference to the minute mechanical structure of substances, notwithstanding the fact that all knowledge of their chemical constitution has come to us through observation of the properties of the substances themselves, and more particularly their relations in cases of double decomposition. Bearing in mind that all terms are relative, I think the chemical constitution of a substance may be defined as the resemblances shown by it in its chemical changes to other substances, often better known than it and taken as types, these resemblances being indicated and described usually by means of special nomenclature and notation. As this nomenclature and notation have been developed out of those designed to express chemical composition, it is well to point out that the notion of chemical constitution is independent of that of the latter, though clothed to some extent in its language and symbols.

The notions of radical and atom are so intimately related as to be often used indifferently, the one for the other. The radical, ethylene, is always an atom of ethylene, the radical nitrogen always an atom of nitrogen. Radical and atom are in fact the qualitative and quantitative aspects of the same thing. They are thus exactly parallel with substance and molecule. We can think of unquantified substance, and perhaps of unquantified radical, but in chemistry we never really want such conceptions; one of the many definitions of science is the quantification of phenomena, and in every chemical phenomenon the substances concerned are quantified as molecules. The quantification of radicals expressed by the atom is fundamentally the same in principle as that of substances, namely, that of chemical equality in interaction; but it may be better to say that it is dependent upon the quantification of substances as molecules.

In the interaction of double decomposition each substance by contact and union with the other develops and manifests a dual character by becoming distributed as the two new substances, with the consequence that each of these has certain properties the same as those of the one, and certain others the same as those of the second interacting substance. What is common in this way to one of the interacting and one of the resulting substances is a radical of these substances, of which there are evidently four in every double decomposition. These radicals of a single interaction are defined as whatever two parts of the powers of a substance to yield the simple substances of its chemical composition are, in certain interactions, continued separately from each other in the two new substances. But the pair of radicals developed in the various double decompositions of a substance being by no means always the same, one of the radicals of one pair must include in its composition part or all of one of those of another pair. Acetic acid has for one pair of radicals methyl and carboxyl, and for another pair acetyl and hydroxyl. Of these, carboxyl includes hydroxyl, and acetyl includes methyl. Again, acetic acid yields the hydrogen and acetate radicals in one interaction, and hydroxyl and acetyl in another, so that in these cases the acetate radical includes acetyl and the hydroxyl includes the radical hydrogen. Now, what is common to carboxyl and acetyl and what is common to the acetate radical and hydroxyl are also treated as radicals, the one being known as carbonyl and the other as the radical oxygen. These are examples of what may be distinguished from the others as the polyvalent radicals. They are radicals of radicals, and therefore also radicals of substances. They may be defined as the common part of two or more other radicals. A single definition of all radicals can be given, but it is not instructive. A radical is any single power or any interdependent association of the powers of a substance to produce simple substances which continue in any product or series of successive products of its chemical change.

Before I leave the subject of the radical I wish to repeat that it is only when it is interacting that a substance shows a dual character or division, as it were, into parts or radicals, and that the duality it then shows is determined as much by the nature of the other substance as by its own. A substance is neither actually nor conceptually the sum of its radicals. The very fact of the difference of these in different interactions should be proof of this; though it only leads to its being taken to be at least the sum of its ultimate or simple radicals. If, however, it is not the sum of its proximate radicals, it is hard to see how it can be imagined to be that of the ultimate ones. In relation to its radicals, a substance must be held to present itself as any one of these for the purpose of investigation, and at the standpoint from which it is considered. It is then to the mind that particular radical, though also something else; just as snow is white and cold, yet also something else, for the moment unconsidered. Nor can the two products of an interaction be looked upon as themselves the sum in properties of the interacting substances. To a limited extent and imperfectly, we can attach to a given radical certain of the properties common to its compounds; but it needs no greater insight than we have already, to recognise that a substance cannot be what it is in one way, without being in that way greatly affected by what it is in another. This is now a recognised but not sufficiently considered point, and I therefore welcome those publications of Professor Vorlaender, of Halle (who now honours this Section with his presence), in which he has been vigorously calling attention to the extent to which the properties of a substance, acid, basic, stable, and what not, depend as much as, if not more, upon the interrelations of the radicals than upon the radicals themselves.

One other thing I have to say about the radical, which is as to the spelling of the word. I plead for a return to the ending of the word radical with 'al,' now interdicted in the 'Journal of the Chemical Society.' It seems appropriate to call the powers of a substance to behave chemically as it does, the roots or radical parts of its chemical nature, but it does not seem appropriate to call them radicles or rootlets. Americans and all other nationalities but our own use the original spelling.

I have put off too long, perhaps, all reference to the properties of very dilute aqueous solutions of salts, but I wished first to discuss the nature of the radical. The osmotic pressure and other dependent points which are particular in the behaviour of such solutions are in full accordance with the assumption that an electrolyte by dissolution in much water becomes a pair or a binary system of two interdiffused quasi-substances called 'ions.' These ions must differ from isolated substances in bearing equal and opposite quantities of electricity; in being each unknown apart from its fellow; and in having a composition not to be found in actual substances, though identical possibly with that which a radical would have were it a substance. The ions can be indeed separated from each other, but not to continue as themselves, since in the act of separating they form ordinary substances, either by uniting with other ions, or by two molecules of ion becoming one molecule of substance. In the former way of separation the ions of two salts interact on mixing their solutions; in the other way, the ions become substances when their solution is placed in a galvanic circuit. In this mode of separation—by electrolysis, that is—the substances corresponding with the two ions, or else secondary products of their change, are produced, the one substance at the kathode and the other at the anode, while the solution away from the electrodes, but between them, remains for the time unaltered in composition. Along with this there occurs in many cases a phenomenon first recorded by Daniell, and afterwards investigated by Hittorf with such beautiful results. This consists in a greater fall taking place in the concentration of the salt solution close to one electrode than in the concentration of that close to the other, as though the ions were hydrate compounds, and that the one ion was a higher hydrate than the other. Until we know more of the nature of the ions themselves this phenomenon is most conveniently quantified on the hypothesis that the ions travel as molecular particles, but the discussion of this hypothesis is beside my present purpose.

The phenomena of ionisation or, in other words, the particular properties of dilute solutions of salts, belong evidently to a change unlike all other chemical changes. It is a polarised chemical change, in which the equivalent and complemental products of the interaction appear apart and at remote surfaces of the mass of decomposing salt solution. Two points which call for notice in connection with my present subject are that an ion is one of a pair of quantities commensurate with the quantity of the salt itself that is or would be in interaction; and that it is molecular in character and therefore to be regarded as a relative and wholly variable quantity.

Dalton's atoms were both the atoms and the molecules of present-day chemistry, but much more the latter than the former. Although the chemical atom can now be no more than a dependency of the molecule, it is commonly set up as the starting-point in chemical theory, and as having an independent existence as a quantity of the substance, while the molecule is represented as being a conjugation of atoms. But there cannot be two standards in reference to the same thing, and in molecular chemistry the atom must give way. As I have already had occasion to point out, the atom is of the radical, the molecule is of the substance.

The four radicals of a double decomposition are equal and chemically complementary. These chemically equal quantities of such radicals are atoms. The quantities of all other radicals are also atoms, but only those of proximate radicals, those of a single interaction, are equal. Similarly, the quantities of the four substances of a single interaction are all equal and are molecules, but the quantities of substances are not equal in other interactions. These others are treated as the simultaneous occurrence of two or more single interactions, which they can always be represented and sometimes demonstrated to be. Calcium hydroxide and hydrogen sulphide give calcium hydrosulphide and water by two single interactions together, which in this case can be easily distinguished, since the calcium hydroxide will also interact with only half as much hydrogen sulphide to form the insoluble crystalline calcium hydroxyhydrosulphide and half as much water as before; this calcium salt will then interact with as much more hydrogen sulphide as went to form it, and produce the very soluble crystalline calcium hydrosulphide. Or the calcium hydrosulphide and as much calcium hydroxide as yielded it will readily interact to form twice as much as the first-obtained quantity of calcium hydroxyhydrosulphide. Thirdly, the calcium hydrosulphide and half as much water as was formed with it from calcium hydroxide readily interact to produce calcium hydroxyhydrosulphide, and half as much hydrogen sulphide as was needed to form the hydrosulphide. Therefore, and on other grounds, we say and know that one molecule of calcium hydroxide and two molecules of hydrogen sulphide give one molecule of calcium hydrosulphide and two molecules of water. This is, of course, only the law of multiple proportions introduced into chemical interactions. The expression 'two or more molecules of a substance' has a meaning only as indicating the number of simultaneous or successive single interactions which have led to the conversion of certain substances into others.

Now a similar but complementary state of things meets us in the case of radicals. Instead of the coefficients of molecules, necessitated by having to consider many chemical changes as being cases of two or more single interactions occurring together, there are the valency coefficients of the polyvalent radicals, called out also by such a compound interaction. Thus, in the above case, whilst the single interaction between hydrogen sulphide and calcium hydroxide shows calciumhydroxyl as one of the radicals, the succeeding interaction between the calcium hydroxyhydrosulphide and more hydrogen sulphide shows the radical calciumhydrosulphuryl, and the common part of these two radicals is the bivalent radical, calcium. It will be evident that to give the atom of the calcium radical as bivalent is a statement reciprocal or complementary to that of giving two molecules of hydrogen sulphide as interacting with one of calcium hydroxide. Chemical equality remains still the measure of the atom, but that, in complex changes, whereas the number of molecules of one substance marks the number of single interactions, the valency number of the atom marks the same thing for the radical. It is a matter of valency, and not otherwise a matter of the atom. The radical calcium is never actively bivalent in a single interaction; in other words, it is never equal to two atoms of hydrogen. As a simple radical it does not take part in such an interaction; but it does do so as a radical of radicals, such as calciumhydroxyl and calciumhydrosulphuryl, and then has the same measure as—is equal in exchange to—the atom of hydrogen, though carrying with it of necessity other radicals, a thing the hydrogen radical never does or can do. To take another example: when acetamide is formed from acetic acid, the nitrogen of the amidogen and the oxygen of the hydroxyl are equal in exchange, but because of their valencies the one carries with it two atoms and the other one atom of hydrogen. This is no matter of merely academic contention, for upon its recognition rests the doctrine of valency itself.

The quantity of the radical is the only proper and sufficient definition of the atom, whether the radical be that of a single interaction, or a radical of radicals, that is, a polyvalent radical. The atom is, therefore, the quantified power of a substance, as the compound of the radical, to produce other compounds of the radical, including its compound with itself, where that is possible. As with the molecule of a substance, so with the atom of the radical, it is of no fixed magnitude, and may weigh a kilogram just as well as only a milligram or something much less. Being a relative quantity and nothing by itself, of its indivisibility there is nothing to be said outside its definition; whilst, as to its being the smallest relative quantity interchanging in an interaction, it had only thus to be defined when there was uncertainty as to the molecule and the single interaction.

It has been impossible for me to discuss the nature of the radical and the atom without referring to valency, but it is itself a subject of such importance as to need special consideration. It does not seem right to me to say even the little I can say about valency without naming with the respect they deserve from us the distinguished chemists who laid the foundations of the doctrine and developed it: Williamson, Odling, Wurtz, Edward Frankland, and Kékulé. I had the good fortune to be in the same laboratory as, and then intimate with, Kékulé, when in 1854 he was working out the bivalency of sulphur and oxygen by his investigation of thioacetic acid, some time, that is, before he had thought out the benzene ring and the valency of carbon.

Only when, as is usual, propositions are made in which a separate and independent existence, with valency as a property, is imputed to a radical, does the question, as to what valency is, present any difficulty. Approaching it from the side of the molecule and of double decomposition, and therefore from the experimental side instead of from that of the radical itself, as is customary, valency presents itself as being the number of single interactions necessary, in order to have a certain radical occur, first as that of one substance, and then as that of another which has no other radical in common with the first substance. That ammonia possesses one atom of the radical nitrogen, and three atoms of the radical hydrogen, and that the nitrogen radical is tervalent and the hydrogen radical univalent are statements mutually based upon facts such as the following. Potassium nitrilosulphate, which contains nitrogen but no hydrogen, is converted by water in a sharply defined single interaction, into potassium hydrogen sulphate, and into potassium imidosulphate, a substance which contains all the nitrogen along now with hydrogen. This salt passes, also sharply and by a single interaction with water, into as much more sulphate along now with potassium amidosulphate, which latter substance contains all the nitrogen and twice as much hydrogen as belonged to the imidosulphate. Lastly, the amidosulphate interacting with water gives a third quantity of potassium sulphate, equal to the last, and also ammonia, having all the nitrogen of the nitrilosulphate started with, three times as much hydrogen as the imidosulphate, and nothing else. That is to say, the nitrilosulphate and the ammonia have no other radical than the nitrogen the same, while three single interactions have been necessary to separate in this way the nitrogen radical from the three atoms of the potassiumsulphonyl radical. Therefore the nitrogen radical is tervalent and its quantity is the atom. Again, there are three atoms of the univalent hydrogen radical in the ammonia molecule, because in each of the three interactions an equal quantity of this radical is brought in from water. Ammonia shows only one pair of radicals, behaving, so far as its own interactions go, exclusively as a compound of amidogen and hydrogen, and these radicals are referred to as united or bound together in being ammonia. It is only the interactions of its derivatives, primary, secondary, and tertiary, that are indicated by treating the amidogen as ultimately nitrogen and two hydrogen radicals. But this involves the consideration of all three hydrogens as bound to the nitrogen; and it becomes, therefore, of vital importance to bear in mind that the hydrogen radical, proper to the ammonia itself, is bound to a nitrogen radical which carries also bound to it two other hydrogen radicals.

Chemical formulæ still remain to be considered. They are symbolisations of deductions from experimentally ascertained facts, and are independent of the interpretation commonly given to them as referring to the minute differentiated structure of substances. A chemical equation expresses a chemical change quantitatively by means of chemical formulæ which are molecular. In a case of double decomposition, therefore, there are four formulæ; but when two or more such interactions are expressed in one equation, because they occur together, the formulæ of transition-substances do not appear, and then numerals before formulæ tell the number of interactions in which separate molecules of the substance have taken part. A formula represents the relative interacting quantity or molecule of a substance, while the single symbols composing it stand each for an atom of the radical of a certain simple substance as possessed by the substance formulated. The connecting lines and dots, and certain collocations of the symbols, indicate the association of the simple radicals as compound radicals in different interactions.

What is symbolised by position formulæ, and indeed by the formula altogether, are the chemical activities and abilities of the substance and its derivatives, and their analogies with those of other substances. When not in interaction, a substance has no constitution and no formula. It is certainly not on any experimental grounds that it can be regarded as some spatial arrangement of unlike parts. To take the simplest case; if we start with sodium hydroxide and symbolise its molecule by some mark, such as X to begin with, the interaction of the substance with an acid leads us to replace the X by two symbols and a connecting mark. One of these will be Na for the sodium radical; let the second be Z for the other radical, and let a dot or stroke be placed between the symbols to mark them as those of a pair of radicals in interaction. In other interactions, such as that with melted potassium acetate, we find need for a new pair of symbols, one being H for the hydrogen radical, while the other may be Q. But it is easy to decompose two molecules of sodium hydroxide in one operation into molecules of sodium, hydrogen, and oxygen, from which fact we learn that Z is replaceable by the double symbol $\mathrm{O{-}H}$, and Q by $\mathrm{O{-}Na}$. Thus, $\mathrm{Na{-}Z}$ and $\mathrm{H{-}Q}$ become equally $\mathrm{Na{-}O{-}H}$, which records the ultimate radicals of sodium hydroxide, together with all its interactions, immediate and remote. But it does this with no more implication of spatially placed and tied parts than is made by expressing the measured flow of time by a straight line, or than is to be found in t^2 seconds of time, or in c^3 as the third power of a number, unless we specifically condition this symbol as stereometric. A formula is not to be read—on experimental grounds, I mean—as a symbol of parts juxtaposed and joined on, and should be regarded as an intricate but legible monogram telling the chemical nature of the substance. Every symbol in it is to call to mind a phase of the chemical activity of the substance or of its derivatives, a phase that may be for the time as the substance itself to the investigator, just as a pigment substance becomes only a red or a white to the painter. For example, salt is often nothing more than its chlorine phase to the chemist when he wants only a soluble chloride; whether it is of potassium, sodium, or ammonium, then matters not to him.

The double linking of the carbons in ethylene is a symbolised expression of facts, without reference to hypothesis. The two carbon radicals of ethane or of alcohol behave together just as does the single carbon of methane or the nitrogen of ammonia in being, but with a valency of six, continued to other compounds devoid of all the other radicals of the ethane or alcohol—that is, of the hydroxyl and the hydrogens. The quadrivalency of each carbon is made up by the interaction necessary to dissociate or to bring together the two methyls, which counts as a unit of valency to each carbon. Ethyl hydrogen sulphate decomposes into sulphuric acid and ethylene, the hydrogensulphate radical with a hydrogen radical becomes the acid as the one product, while the methylene radicals again pair off as the two methyls had done when ethane was formed, thus producing the non-saturated substance, ethylene. Since there is a perchlorethylene, the second linking mark falls between the two carbons; and when ethylene passes back to an ethane compound two units of valency are displayed by it without the carbons becoming dissociated.

Position formulæ of isomerides, such as those of propyl alcohol and acetone, present no difficulty, because they are interpreted as the expressions of unlike double decompositions. It is not unfrequently the case that no constitutional or structural formula can be given to a substance which shall express all the pairs of radicals possible in its interactions, of which the best-studied example is that of ethyl acetoacetate. This state of things, known as tautomery, admits of no other interpretation than that there are really two substances existent, of which one only is known, the other or so-called 'pseudoform' requiring the assumption of its existence as a transition-substance only. The notion of the shifting hydrogen radical is but the hypothetical way of viewing the intervention of the intramolecular change by which the substance becomes its 'pseudoform.'

The cyclic formula of benzene expresses the fact that, unlike a fatty hydrocarbon, benzene shows but one pair of interaction radicals, hydrogen and phenyl. The 'ortho-,' 'meta-,' and 'para-' positions in benzene derivatives are only expressions of facts of 'position' isomerism, such as those pertaining to other non-saturated compounds, but more complex to unravel and more varied and interesting. It is doubtful whether the Kékulé ring does not remain as efficient a symbol as any stereographic substitute yet proposed for it; but it itself is purely a symbol of chemical interactions, and has no spatial significance other than what may be put into it by convention. 'Adjacent,' 'opposite,' and the like have only application literally to the arrangement of the symbols; but if the symbolisation is perfect the 'opposite' carbons will, as a matter of course, always indicate the same point concerning the chemical interactions.

Whether the chemical formulæ for the lactic acids are better arranged in a plane or as a tetrahedron is to be decided by the facts concerning these and other asymmetric carbon compounds, the object being to symbolise or formulate as distinct and complementary in certain physical properties, but alike in their chemical interactions, two isomeric substances, simultaneously formed in molecular quantities. Enantiomorphous arrangements of the respective formulæ of dextro- and lævo-lactic acids fully meet the case, but the facts are in no way explained by these formulæ. In the enantiomorphously related hemihedral crystals of the corresponding salts of the dextro- and lævo-acids, and in their opposite rotatory effect in solution upon the plane of polarised light, we recognise something like a torsioned state of the whole homogeneous substance, something to be accounted for by peculiarity of chemical origin, but not something made more intelligible by any imagined arrangement of unlike parts. It is possible to give an account of the chemical facts without making reference to mechanical structure, and then to reason about them somewhat in the following way: Given the case of a substance doubly equipped with the power to take part in a certain interaction, and considering that the exercise of the power can only be single, and that it cannot be made without affecting and transforming, or perhaps nullifying, the second equipment with power, predict what will happen. That is the prediction called for concerning any interaction which generates an asymmetric carbon compound. The result could never have been predicted; yet how natural and beautiful it is when it comes to us through experiment enlightened by the genius of Pasteur, Le Bel, and Van 't Hoff! That answer is that a twinned substance results, one indeed in most respects and chemically, but two in certain physical properties, characterised by presenting phenomena as of equal and opposite strains, a polarised pair of substances, in fact. What I mean by the double equipment with power is, of course, the pair of identically related and self-identical radicals, or the bivalency of one radical wholly and directly associated with the carbon radical. The case of the oxygen radical of aldehyde is that of the bivalent radical; the other case is that of the two carboxyl radicals of hydroxytartronic acid, or that of the two methylene hydrogen radicals of alcohol which these carboxyls have replaced. The tetrahedral formula with its reflected form admirably symbolises the case of enantiomorphously related pairs of substances. But no light whatever is thrown upon the nature of this pairing by the tetrahedron model; its value depends upon the fact that as a symbol it so fully matches the constitution of the substances.

Here I bring my summary of chemical theory and its formulation without hypothesis to a conclusion, hoping that, to some extent, I may have impressed you with the fact that the exposition of even advanced chemistry, in its symbolic, equally as in its ordinary language and nomenclature, is independent of any hypothesis as to the mechanically and chemically differentiated structure of substances, and that chemistry can be studied and still furthur developed without reference to such a structure. I have asked for few or no reforms in the use of either terms or symbols, my point having been only to press for a consideration and discussion of the doctrines of chemistry and the great atomic theory itself as something concerned exclusively with experimental chemical facts.

The following Papers were read :—

1. *On the Corrosion of Copper by Sea-water, and on the Detection of Traces of Impurity in the Commercial Metal.* *By* Professor E. A. LETTS, *Ph.D.*

2. *On Experiments to Ascertain the Amount of Carbonic Anhydride absorbed from the Sea-water by Air.* *By* Professor E. A. LETTS, *Ph.D.*, *and* W. CALDWELL, *B.A.*

3. *The Action of Distilled Water upon Lead.*
By Professor FRANK CLOWES, *D.Sc.*

When lead is placed in contact with ordinary distilled water chemical action becomes evident by the formation of a white deposit which contains lead, and lead is also found in solution by chemical tests.

The lead appears to exist in solution in the form of hydroxide, since it is removed by passing the liquid through filter-paper: this fixation by cellulose of the dissolved hydroxide is one of the marked properties of the hydroxide. The hydroxide is readily removed from the cellulose by dilute acetic acid.

An examination of the white deposit proved that it was a hydroxycarbonate containing three molecules of carbonate to one of hydroxide.

It would be inferred from the above facts that the lead is probably converted into hydroxide by the action of the dissolved oxygen, and that the subsequent action of the dissolved carbon dioxide converts the hydroxide into hydroxycarbonate.

It would appear improbable that even bright lead can decompose water with formation of hydroxide. But the opinion has prevailed that the action of distilled water on lead is promoted by the presence of carbonic acid.

The nature of the action of distilled water upon lead was studied by exposing bright lead, both *in vacuo* and in an atmosphere of hydrogen, to distilled water which had been freed from its dissolved gases by boiling, and then introducing either oxygen alone, carbon dioxide alone, or mixtures in varying proportions of oxygen with carbon dioxide.

Bright sheet lead of great purity when exposed to boiled distilled water *in vacuo* or in an atmosphere of hydrogen was acted upon only to an infinitesimal extent (0·3 part of lead to one million parts of water). This result was probably due to the impossibility of removing the last traces of oxygen, and it negatives the suggestion of any direct action of water upon lead.

When the lead was exposed to the water in the presence of the different artificial atmospheres, the action reached its greatest extent (0·023 part of lead per 100 of water) when oxygen alone was present; with carbon dioxide the action was slight (0·008 per cent.); with equal volumes of oxygen and carbon dioxide about an equal effect was produced; while with eight volumes of oxygen to one of carbon dioxide the extent of the action approached that due to oxygen.

It is evident, therefore, that dissolved oxygen is the cause of the action of distilled water upon lead, the subsequent action of carbon dioxide leading to production of hydroxycarbonate. It is further evident that the presence of carbon dioxide in any large proportion exerts an inhibitory effect upon the action.

When sheet lead is immersed in ordinary distilled water with free exposure to air, it is found that the rate of action is diminished by entire immersion as compared with partial immersion, but that in both cases the total result produced is ultimately the same.

In the earlier stage of the above inquiry the ordinary aërated distilled water was freed from its dissolved gases by being boiled in glass vessels. When this water was allowed to reaërate itself by exposure to the air, it did not regain its original power of acting upon lead. This was found to be due to the inhibitive power of silicates dissolved from the glass, and the inhibitory power varied with the degree of solubility of the glass when vessels composed of different kinds of glass were used. Boiling the water in glass or condensing the steam in glass tube condensers led to the inhibitory effect, but contact of cold distilled water with cold glass did not produce the result. Complications arising from this cause were avoided in later experiments by distilling the water from a copper vessel and condensing the steam in a copper tube condenser.

The action of distilled water, or of soft waters generally, upon lead may be considerably reduced by dissolving various substances in the water. Sulphuric acid or a sulphate was found to be most efficient for this purpose, carbonic acid and carbonates proved less efficient, lime water was still less effective, and even promoted the action when it was used in larger proportion.

It has been stated that the action of water upon lead is due to the presence of bacteria or their products. This cause of action was removed in many of the present experiments by using water which had been freely distilled and then boiled for a long time, and by bringing it into contact with lead which had been melted for some time in a sterilised flask. When air filtered through cotton wool was admitted into the flasks, the action on the lead commenced at once and proceeded to the full extent which is attained when ordinary lead is immersed in ordinary distilled water.

FRIDAY, SEPTEMBER 12.

The following Papers and Report were read:—

1. *Hydro-Aromatic Compounds with Single Nucleus.*
By A. W. CROSSLEY, *D.Sc., Ph.D.*—See Reports, p. 120.

2. *The Undesirability of Establishing Standard Analytical Methods.*
By BERTRAM BLOUNT.

The author directed attention to the growing tendency at the present time to apply the principle of standardisation in novel directions. He discussed the utility of standardisation in general, and concluded that while undoubtedly necessary for such things as weights, measures, and money, its desirability for wire and sheet gauges, screw threads, and the like is less incontestable, and the advantage of its application for fixing the dimensions of such structural materials as rails and rolled joists is debateable. Still more doubtful is the value of standardising methods of mechanical testing as used for materials employed in construction. The author holds that in these disputable cases, convenience and expediency should be the sole criterion. The manufacturer is usually in favour of standardisation, but some caution must be exercised in accepting this preference as evidence of the merit of the process. The application of the principle of standardisation to chemical analysis was then discussed. An historical *résumé* was given of the attempts which have been made to introduce standard methods of analysis of various materials. The work of the British Association in providing standard samples of steel was dealt with, and a distinction drawn between this undertaking and the establishment of standard methods for the analysis of steel. Reference was made to the activity of American chemists in promoting the use of standard methods of analysis.

The author considers that the discordant views held by different chemists as to the desirability of standardising methods of analysis is due in some degree to want of mutual understanding. There are many arbitrary methods in use, *e.g.*, for the examination of water, oils, milk, butter, asphalte, manures, and feeding-stuffs, which should be standardised. True analytical processes, such as the determination of all elements, most inorganic compounds, and many well-defined organic bodies, cannot usefully be standardised. The plea for standardisation owes what force it possesses to a confusion of these two branches of work. The author holds that the selection of a method for the determination of a chemical entity must be left to the discretion of the trained chemist, and that the imposition on him of a standard method is undesirable, and in practice unattainable.

The agitation for standard methods has arisen in great measure from the occurrence of discrepancies in analysis which are inconvenient to the trader and injurious to the chemist. These discrepancies are due to bad sampling and unskilful work, and will not be remedied by standardisation. The remedy consists in more careful sampling, and in more accurate and skilful analysis. Uniformity of results will thus be obtained irrespective of uniformity of method.

The situation of the works' chemist was considered, and the conclusion reached that he must be better trained and better paid. The extra cost to the manufacturer will be recouped by the greater help afforded by the chemist.

While desirous of confining standardisation to the chemical examination of substances for which arbitrary processes alone are available, and while condemning all attempts to standardise analysis properly so called, the author is of opinion that something more than a policy of *laisser faire* can be usefully undertaken. He advocates conferences of specialists in different branches of analysis for the description of methods and their critical discussion. These conferences should be purely for the advancement of knowledge, and not for the promulgation of rules. By their influence the standard of accuracy in analysis would be raised, and concordance of results secured without recourse to the use of arbitrary and conventional methods.

3. *The Decomposition of Urea.*[1] *By* CHARLES E. FAWSITT, *Ph.D.*

The author has studied the decomposition of urea into ammonia and carbonic anhydride in aqueous solution at 99° C. as a problem in reaction velocity. The reaction in presence of either acid or alkali would be expected theoretically to be bi- or tri-molecular, but the experimental results show that in these cases, and also when pure water is used as the solvent, decomposition proceeds in accordance with the formula of a monomolecular reaction. This apparent anomaly is explained by assuming the formation of an intermediate product—namely, of ammonium cyanate; further, the presence of this salt in the solution, as an intermediate product and not as a by-product, has been proved. The hydrolysis of urea is therefore not a case of direct saponification.

4. *Report on the Relation between the Absorption Spectra and Chemical Constitution of Organic Substances.*—See Reports, p. 99.

5. *Recent Synthetical Researches in the Glucoside Group.*
By DR. E. FRANKLAND ARMSTRONG.

If anhydrous hydrogen chloride or bromide be allowed to act at ordinary temperatures on either of the two isomeric pentacetyl-derivatives of glucose, the acetyl radicle attached to the aldehyde group is quantitatively displaced by halogen, giving rise to isomeric aceto-halogen-glucoses, which are well-defined crystalline substances. These compounds are of considerable value as synthetical agents. One of them was made use of by Michael some twenty years ago, in the form of a syrup, in effecting the synthesis of helicin and some other glucosides derived from the phenols. In practice the interaction between the halhydride and the acetyl-derivative is carried out in sealed tubes, the gases being liquefied by the aid of liquid air. When the interaction is at an end the tubes are again immersed in liquid air in order to allow of their being safely opened. The aceto-halogen-glucoses are completely converted into the alkylglucosides by treatment with alcohols, giving rise, when methyl alcohol is used, to the known α- and β-methylglucosides.

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[1] *Zeitschrift für physikalische Chemie*, xli. 601.

As the glucosides are obtained in a pure state by this method they crystallise ithout much difficulty. The β-derivatives are specially easy to obtain, whereas hen Fischer's method is used, which involves heating a mixture of the sugar d alcohol together with a small quantity of chlorhydric acid, the greater part the product is the α-glucoside; the methods therefore supplement one another. series of alkyl derivatives of glucose and of galactose have been investigated.

Aceto-halogen-derivatives of both maltose and milk sugar have been prepared id the former converted into the corresponding β-methylmaltoside—the simplest se of a trisaccharide. The behaviour of this compound towards enzymes is ecially interesting. As Fischer has shown, maltose is an α-glucoside,[1] but in e synthetic compound the methoxy-group is introduced in the β-position. ethylmaltoside is, in fact, a double αβ-glucoside similar to the natural gluco- le amygdalin, and resembles this latter in its behaviour with yeast maltase, the altose part of the molecule being hydrolysed, so that methylglucoside and ucose are formed; on the other hand, when subjected to the action of emulsin, e maltoside is resolved into methyl alcohol and maltose. An exactly analogous haviour is shown by the corresponding phenolmaltoside.

Recently, β-acetochloro-derivatives of sugars have been prepared by Skraup by e action of phosphorus pentachloride and aluminium chloride on the pentacetyl- rivatives; but in this case molecular rearrangement takes place, both the α- id β-pentacetates giving the same chloro-derivatives. The investigation carried it by the author has shown that the β-halogen-derivatives are the more stable, id that in presence of alkali the α- are rapidly converted into the β-derivatives, hich is a definite proof that the isomerism and likewise that of the glucosides stereochemical. This instability has unfortunately prevented a synthesis of e α-glucosides of the phenols; and it is of interest to note that nearly all the itural glucosides which have been physiologically tested belong to the β-series.

6. *The Synthetical Action of Enzymes.*

By Dr. E. Frankland Armstrong.

It has long been known that enzymes have the power of inducing hydrolysis, irticularly of disaccharides containing a 'glucoside-linkage,' but the observation Croft Hill that enzymes can also effect synthetical changes is of quite recent ite; his experiments have shown that when maltose is hydrolysed by maltase, ist as in the case of the hydrolysis of esters by acids, a reversible action takes ace in concentrated solutions; and that in concentrated solutions of glucose a saccharide is formed. Some uncertainty exists as to the nature of this sugar, ill claiming that it is maltose, whereas Emmerling contends that he has identified by means of the phenylosazone with isomaltose. Bearing in mind the great fficulty experienced in purifying and characterising the osazones of disaccharides, is impossible, on the strength of this one derivative alone, to decide the ques- on; but as Emmerling has shown that the sugar formed is not fermented by top yeast,' it may be concluded that it cannot be maltose.

Croft Hill's conclusion that enzymes exercise synthetic functions has been stified by the later observations of Kastle and Loevenhart and of Hanriot on pase, the enzyme by which fats are hydrolysed, these observers having shown at this enzyme is capable of producing both esters of fatty acids and glycerides. these cases stereochemical isomerism is out of the question, and the products are entical with the natural substances. Emmerling has also demonstrated that the nthesis of amygdalin from mandelio-nitrile glucoside and glucose may be effected means of maltase.

It is interesting to note that Fischer has proved that isomaltose, not maltose, is rmed by the action of acids on glucose, showing that in their case the action not strictly analogous to the reversible hydrolysis of esters by acids, and it is, therefore, the more probable that isomaltose should be formed by the action of enzymes, as their behaviour in other respects resembles that of acids. Unfortunately nothing is known as to the relationship of isomaltose to maltose, and it is impossible to say whether they are merely the α- and β-glucoside forms, or whether they differ as regards the carbon atom to which the glucoside linkage is attached.

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[1] α-glucosides are those hydrolysed by maltase, β-glucosides those hydrolysed by mulsin.

The author has been engaged in studying lactase in conjunction with Professor E. Fischer, and they have been able to demonstrate that this enzyme is one of those which are capable of inducing synthetical changes.

It was found that, whereas the action of lactase on milk-sugar was at first hindered and ultimately stopped entirely by the presence of the monosaccharides to which it gives rise, when the amount of these was further increased a change in the reverse direction took place. Accordingly the enzyme was kept for some time at 35° in a concentrated solution containing equal parts of galactose and glucose, toluene being added as an antiseptic. Both the reducing power and the optical rotatory power of the solution diminished steadily, and the phenylhydrazine test showed that a sugar was present capable of forming an osazone which was easily soluble in hot water. The tests, in fact, united in proving that a disaccharide had been produced. After three weeks the rotatory power of a 50 per cent. solution had fallen by about 16–20 per cent., indicating that roughly 20–25 per cent. of the glucose had been converted into disaccharide; this conclusion was confirmed by the change in the reducing power. The isolation of the sugar in a pure state has not yet been effected.

The properties of its phenylosazone resemble those of phenyllactosazone. More light has been thrown on the nature of the sugar by the study of its behaviour towards other enzymes. Having proved that the sugar—which has been termed provisionally *Isolactose*—is unfermentable by 'top yeast,' the solution, obtained in the manner described, was boiled, diluted, and subjected to fermentation in order to remove the major portion of the unchanged monosaccharides; it was then concentrated, and its behaviour studied towards 'bottom' yeast, emulsin, and kefir lactase. All the usual precautions were observed, the extent to which changes took place in the solution was ascertained by determining its reducing power and its rotatory power, when possible, and especially by means of the phenylhydrazine test.

In this way it was proved that, whilst isolactose is entirely fermented by 'bottom yeast,' and hydrolysed by lactase, emulsin is without any action upon it. Tabulating the behaviour of the natural and synthetic sugars, it is obvious that the two are distinguished by their behaviour towards bottom yeast and emulsin; their relationship is, therefore, of the same order as that which obtains between the α- and β-alkyl-glucosides.

	Top Yeast	**Bottom Yeast**	**Emulsin**	**Lactase**
Milk-sugar . .	unchanged	unchanged	hydrolysed	hydrolysed
Isolactose . .	unchanged	fermented	unchanged	hydrolysed

It is, at any rate, certain that milk-sugar is not formed, so that in the case of lactase, as in that of maltase, a sugar isomeric with that normally hydrolysed by the enzyme is obtained as the product of its synthetic activity.

Lactase also exercises a reversible action, though to a much less extent, in a concentrated solution of glucose. In this case, also, a disaccharide is formed which is characterised by yielding a very soluble phenylosazone. On the other hand, little or no synthetical action is effected by lactase in a solution of galactose.

Finally, experiments carried out in an exactly similar manner with *emulsin* show that this enzyme is also capable of effecting synthetical changes, and that it acts in a particularly rapid manner. The maximum of reversion is effected in a concentrated (50 per cent.) solution containing equal parts of glucose and galactose, an equilibrium being arrived at when about 20 cent. of disaccharide is present. Reversion also takes place in a concentrated solution of glucose under the influence of emulsin. The products afford phenylosazones which are easily soluble in hot water, and are not fermented by top yeast, but easily by bottom yeast.

It may therefore be regarded as established that the enzymes which induce the hydrolysis of glucosides are also capable of acting reversibly in concentrated solutions of the glucoses; the disaccharides which are thus produced, however, are isomeric, not identical with those normally hydrolysed by the enzymes, and in this respect, therefore, the condensing action of enzymes is comparable with that of concentrated solutions of mineral acids.

7. *The Telluric Distribution of the Elements in Relation to their Atomic Weights.*[1] *By* WILLIAM ACKROYD, *F.I.C.*

In the endeavour to arrive at new facts respecting the distribution of the elements, the purchasing power of a given sum is taken as an indication of plenty or rarity. Thus four guineas will buy 1 ounce of gold, 42 ounces of silver, and 2,286 ounces of copper; 188 ounces of sodium, 26 ounces of potassium, 0·065 ounce of rubidium, and 0·029 ounce of cæsium. In each of these natural groups the rarity of the element, as indicated by such distribution figures, increases with atomic weight. The limitations of the method are dealt with. Some forty-five examples are calculated and tabulated.

The results of calculations of the absolute telluric distribution of chlorine, bromine, and iodine are also given, as follows:—

a	*b*	*c*	$\frac{c}{b}$
	Atomic weight	Relative distribution in per cent. of earth's mass	Atomic distribution
Cl	35·5	$4·86 \times 10^{-4}$	$0·136 \times 10^{-4}$
Br	80	$5·83 \times 10^{-6}$	$0·0728 \times 10^{-6}$
I	127	$5·83 \times 10^{-8}$	$0·0459 \times 10^{-8}$

The inverse relation of distribution to atomic mass here is pointed out, and also the remarkable fact that as bromine is intermediate in mass, so also is it intermediate in absolute telluric distribution in this group.

The cosmical importance of the subject is shown in dealing with the exceptions—some of the lightest non-metals and the heaviest of metals. The general conclusion is drawn that in the genesis of the elements from protyle less and less atoms of highest mass were evolved, and that the universe became pervaded by the greatest quantity of those atoms which have the lowest masses.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Papers and Reports were read:—

1. *Our Present Knowledge of Aromatic Diazo-compounds.* *By* GILBERT THOMAS MORGAN, *D.Sc., F.I.C.*—See Reports, p. 181.

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[1] Published in full in the *Chemical News*, vol. lxxxvi. p. 187.

2. *The Colour of Iodine-containing Compounds.* *By* Miss IDA SMEDLEY.

Professor H. E. Armstrong[1] has for some years contended that a generalisation may be made as to the molecular structure of substances which are visibly coloured in the conventional acceptance of the term, since almost all coloured organic substances may be represented by a 'quinonoid' structure, if the term 'quinonoid' be regarded as including any compound which contains at least three centres having some influence on the passage of light through the molecule. From this point of view he regards iodoform as a quinonoid substance in which the three iodine atoms act as centres co-operating to produce colour.

Substances containing iodine may be divided into two classes—coloured and colourless. Does any distinctive similarity of structure exist in the coloured iodine-containing compounds?

Of the molecular condition of solid iodine nothing is known; in solutions the number of atoms in the molecule probably lies between two and four.[2] The violet vapour up to 700° C. consists of di-atomic molecules; but completely dissociated or gaseous mon-atomic iodine is described as colourless. The iodine halogen compounds are also coloured, the mono-chloride much more intensely than the trichloride. When iodine acts as a trivalent element, combination with one chlorine atom is insufficient to produce colour: thus di-phenyl iodonium chloride (IPh_2Cl) is colourless, but phenyl iodide chloride ($IPhCl_2$) is yellow.

Since the iodine atom itself is probably colourless, the colour of the compounds must be attributed to the mutual effect of the halogen atoms. Further, a comparison of the iodine chlorides shows that the tendency to produce colour is greater where the iodine atom is not fully saturated.

Amongst the compounds of iodine with other elements, the readiness with which double iodides are formed, the comparative insolubility of many of the iodides, and the colour-changes they undergo on heating, suggest that their molecular structure is more complex than is usually represented. Nearly all the mono and divalent elements give colourless iodides, and it is probable that the coloured di-iodides are really polymerised. Mercuric iodide, for instance, which exists in two coloured isomeric forms, gives a colourless vapour, the density of which corresponds with the simple formula HgI_2. Among organic substances the exceptional case of di-iodoacetic acid and its salts,[3] which are all described as yellow, needs further investigation.

In the case of tri-iodides and higher iodides generally, the appearance of colour is determined, not only by the number of iodine atoms present, but also by the condition of the iodine. Thus the nitrogen group of elements form deeply coloured tri-iodides, while the tri-iodides of boron and aluminium are colourless. In hydrocarbon derivatives the three iodine atoms must be associated with the same carbon atom in order to produce colour, as in iodoform; poly-iodo-derivatives in which the iodine atoms are joined to different carbon atoms, as in tri-iodo-benzene, being colourless.

3. *On a Fourth Methylmorphimethine.*[4] *By* J. HAWTHORNE, *B.A.*

Three isomeric methylmorphimethines have been up to the present described, whilst the most recent formulæ suggested for these bodies indicate the existence of a fourth.

α-methylmorphimethine was first obtained by Hesse and Grimaux by the action of caustic potash upon codeine methiodide; by the action of alcoholic potash and other reagents it yields β-methylmorphimethine.

The third isomer was prepared by Schryver and Lees[5] by the action of caustic potash upon isocodeine, and was named by them methylisomorphimethine;

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[1] *Proc. C.S.*, 1892.

[2] Loeb., *Trans. C.S.*, 1888.

[3] Perkin and Duppa, *Annalen*, 185.

[4] The paper is published in full in the *Berichte*, xxxv. p. 3010.

[5] *Trans. C.S.*, vol. lxxix. 1901.

lthough they ascribe to it a different structure from the α- and β-compounds it nay for the sake of uniformity be called γ-methylmorphimethine.

Working under the direction of Professor Knorr, of Jena, the author has btained a fourth isomer—δ-methylmorphimethine—by boiling the γ-derivative or some time with alcoholic potash, a method analogous to that used in preparing he β- from the α-form. δ-methylmorphimethine forms well-defined prismatic rystals: it is sparingly soluble in ether, but easily in methyl and ethyl alcohols, hloroform, benzene, ethyl acetate, and acetone. It melts at about 112° C., and n methyl alcohol it gives a specific rotation of +256°.

The methiodide of δ-methylmorphimethine crystallises from water in rect-ngular plates, melting at 282° C. and giving the specific rotation +151°. It an also be prepared directly from the γ-methiodide by boiling the latter for ome time with dilute caustic potash. A similar transformation of α- into β-methiodide was effected by Hesse.

The benzoate of the new base crystallises in fine needles, and in 99 per cent. alcohol has a specific rotation of +181°, as against +41° for the γ-derivative.

The research is not yet finished, but the results already obtained support the theory as to the existence of two asymmetric carbon atoms in the molecule of morphine and its immediate derivatives.

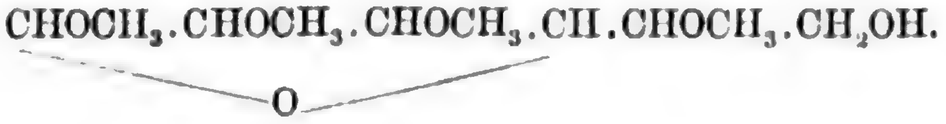
4. *The Alkylation of Sugars.*

By Thos. Purdie, *F.R.S., and* James C. Irvine, *B.Sc., Ph.D.*

The method of alkylating hydroxyl groups by means of a mixture of silver oxide and alkyl iodides does not appear directly applicable to aldoses or ketoses, and results in oxidation and subsequent changes of some complexity. By means of this reaction, however, the authors have succeeded in alkylating methyl glucoside with the formation of tri-methylic and tetra-methylic methyl glucoside ethers, compounds from which alkylated aldoses can presumably be obtained on hydrolysis.

Tri-methylic methyl glucoside ether.—The methyl glucoside used in the preparation was obtained by heating glucose in CH_3OH solution with HCl for fifty hours at 100°. The glucoside (melting-point 165°-167°) was dissolved in boiling methyl alcohol, and a large excess of the alkylating mixture, in the proportion of two molecules iodide to one of oxide, gradually added. After all action ceased, the mixture was boiled under a condenser for over an hour, and filtered.

On removal of the alcohol, the filtrate was extracted with ether, and after drying and evaporation, the *neutral* syrupy extract was distilled in vacuum from a graphite bath. An extremely thick colourless liquid passed over between 155°-157° under 12 mm. pressure, and after refractionation a sample gave on analysis figures in close agreement with the calculated numbers for tri-methylic methyl glucoside ether:



$$\underbrace{CHOCH_3.CHOCH_3.CHOCH_3.CH}_{O}.CHOCH_3.CH_2OH.$$

A molecular weight determination showed that no rupture of the molecule had occurred, and the methoxyl content of the compound was confirmed by Zeisel determinations.

The higher fractions obtained in the vacuum distillation were extremely thick, and the results of analyses showed these to consist of incompletely methylated glucoside.

Tri-methylic methyl glucoside is optically active, a 5 per cent. solution in alcohol showing a specific rotation of +126·75° at 20°, whilst for the pure substance $(\alpha)_D^{20^\circ} = +129{\cdot}27^\circ$. The compound is soluble in water, alcohol, ether, and methyl iodide, and the aqueous solution has no action on Fehling's solution until hydrolised with HCl, when the aldose produced in the reaction effects ready reduction.

Tetra-methylic methyl glucoside.—This compound was prepared by adding silver oxide to a solution of the tri-methylic ether in a large excess of methyl iodide, and boiling the mixture for several hours. After filtering and evaporating, the product was distilled in vacuum, and tetra-methylic methyl glucoside obtained as a colourless fairly mobile liquid, boiling at 144°–145° under 17 mm. pressure. In different preparations the boiling-point was the same, and satisfactory results were obtained in the combustions and Zeisel determinations. The specific rotation at 20° of the pure substance proved to be $+127{\cdot}88°$, whilst a 5 per cent. solution in alcohol gave $(a)_D^{20°} = +127{\cdot}78°$.

Hydrolysis of the Compounds.

Both tri-methylic and tetra-methylic methyl glucoside when hydrolised give compounds capable of reducing Fehling's solution, and therefore probably containing an 'aldose' structure. On hydrolysis of the tri-methylic ether by means of 20 per cent. HCl, a colourless gum was isolated from the reaction products, which, after drying at 110°, gave figures on combustion approximating to those required for tri-methyl glucose. The substance reduced both Fehling's solution and an ammoniacal solution of silver nitrate, and a qualitative Zeisel experiment showed that the methoxyl groups had survived the hydrolysis. So far this body has not been obtained in a state of purity, but we are at present engaged in the preparation of the compound on a larger scale, with a view to examining its properties and investigating the special reactions of which it is capable. We likewise hope to publish shortly an account of the alkylated glucose obtainable from the tetra-methylic methyl glucoside, and to continue our experiments on other alkylated sugars which are already partly prepared and examined.

Alkylation of Acetone-rhamnoside.

According to Fischer's formula for acetone-rhamnoside, the compound contains two hydroxyl groups, and we find that the silver-oxide reaction can be successfully carried out on the substance with the formation of di-methylic acetone-rhamnoside.

The rhamnoside, when dissolved in acetone, reacted energetically with silver oxide and methyl iodide, and after filtration and evaporation the product was distilled in vacuum. Complete alkylation was, however, only obtained by dissolving the distilled product in methyl iodide and repeating the treatment with silver oxide. On distillation, a colourless pleasant-smelling oil was obtained (boiling-point = 115°–118° under 11 mm. pressure), which the combustion and Zeisel results showed to be di-methylic acetone-rhamnoside.

The compound is soluble in the ordinary organic solvents, and has scarcely any action on Fehling's solution until hydrolised with HCl.

A 5 per cent. solution in acetone had a specific rotation of $-24{\cdot}64°$ at 20°, this result being in sharp contrast to the value of $(a)_D$ for the parent substance, which equals $+17{\cdot}4°$.

Presumably the compound on hydrolysis splits off a molecule of acetone and gives a di-methylic rhamnose, just as the rhamnoside itself yields acetone and rhamnose. We are at present engaged in the investigation of this reaction, and it is our intention to examine the hydrolysis product in detail, with a view to establishing its reactions and constitution.

5. *Report on the Collections of Statistics concerning the Training of Chemists employed in English Chemical Industries.*—See Reports, p. 97.

6. *Report on Isomeric Naphthalene Derivatives.*—See Reports, p. 176.

7. *Report on Isomorphous Sulphonic Derivatives of Benzene.* See Reports, p. 180.

8. *The Reduction of some Metallic Chlorides by Calcium Carbide. By* Major W. E. Edwards, *R.A.*, Captain C. H. Liveing, *R.A.*, *and* Professor W. R. Hodgkinson, *Ph.D.*, *F.I.C.*, *F.R.S.E.*

Many metallic oxides are reduced to the metal when heated with calcium carbide. It is, however, an inconvenient reducing agent for oxides on account of its infusibility.

It occurred to us that it might be useful in the case of some metals, as cerium, chromium, manganese, and others, the oxides of which are not easily or not practically reducible by carbon in ordinary furnaces, if it would act upon the chlorides or fluorides of these metals.

The first experiments were made with cerium chloride simply because we were trying to obtain some alloys of that metal.

Cerium oxide is easily converted into chloride by heating with an excess of ammonium chloride. On heating a mixture of this chloride with finely powdered carbide there was a decided reaction in so far that calcium chloride was formed and an infusible black granular substance which appeared to be a compound or mixture of cerium and carbon with some unchanged carbide.

A mixture of cerium chloride, calcium carbide, and copper in filings gave in the first experiment an alloy of copper and cerium containing about 6 per cent. of the latter metal. This alloy is very tough, but not appreciably harder than commercial copper.

We have since obtained alloys considerably richer in cerium, and we are examining the properties of some alloys of this metal and also of didymium with copper.

Manganese chloride is equally, if not more easily, reduced by carbide, and we find it a comparatively easy method of formation of manganese-copper alloys.

Iron and nickel are not quite so convenient to employ with carbide, as much carbon is taken up.

TUESDAY, SEPTEMBER 16.

The following Papers and Reports were read:—

1. *Colloids of Zirconium, compared with those of other Metals of the Fourth Group. By* Dr. J. H. Gladstone, *F.R.S.*, *and* Walter Hibbert, *F.I.C.*

On continuing the experiments on colloids, which were described in their papers at Dover and Glasgow, the authors found that zirconium gave a colloid of well-marked properties, resembling those of silicon, tin, titanium, and thorium. The tetrachloride of zirconium is a volatile pungent body which, reacting with water, forms hydrochloric acid, and various oxychlorides or hydroxides. The gummy mass so obtained, when dried, gave beautifully regular forms of fissures and spirals. The gummy solution, when heated, formed a gel which, when exposed to the air, gradually lost water. Successive diffusates from this gel gave various crystalline forms on evaporation. The first diffusate was particularly rich in dagger-shaped crystals with rounded edges, which proved to be oxychlorides. In later diffusates this compound was gradually replaced by crystals of other forms, similar to what had been previously observed among the colloids of tin and titanium, and which appeared to be free from chlorine. These crystals were extremely labile, and exhibited forms always more or less curved in their outlines. The solutions of these colloids of zirconium, tin, and titanium slowly formed crusts or skins which were insoluble in water, and which slowly shrank, often cracking in irregular patterns. It is a curious circumstance that the solution of zirconium colloid very readily produces spongy growths, similar in appearance to those that have previously been observed in solutions of silicon. All these colloids seem to be marked by the extreme readiness with which the hydroxyl element replaces more or less chlorine, and by the number of molecules of water with which they will combine.

2. *On Fluorescent and Phosphorescent Diamonds.*

By Dr. J. H. GLADSTONE, *F.R.S.*

In the 'Comptes Rendus,' 134, M. Chaumet describes the fluorescence excited in diamonds by violet light, and considers that this effect is strongest in the best and most valuable stones. He describes an experiment with a certain yellow diamond which showed no fluorescence under violet light, but after a few minutes' exposure became dark brown, regaining, however, its original colour and brilliancy in the course of twenty-four hours.

This communication has led the author to refer to the fact that at the Aberdeen Meeting of the British Association in 1859 he exhibited and described a diamond ring, three stones in which were somewhat fluorescent by daylight, and which phosphoresced in the dark after exposure to sunlight. The Rev. Dr. Robinson showed this phosphorescence to his audience in one of the evening lectures. These diamonds were more fully examined afterwards, and it was found that they shone most brightly when exposed to the violet and ultra-violet rays: but the length of time that the phosphorescence in the dark lasted seemed to vary with the manner or length of previous exposure in a way not to be easily explained. This led the author to examine the very valuable jewellery of a personal friend; not one of her diamonds exhibited this phenomenon, which suggested the idea that the property in question was due to some impurity not usually found in diamonds of the first water. A few years ago Professor Silvanus Thompson exhibited this ring during the course of a lecture on some phenomena of light at the Royal Institution. The diamonds shone very brilliantly, but afterwards they entirely lost their phosphorescent power. They were kept in the dark, and in the course of a year or so the power of phosphorescing was restored, though not to its former extent. These tests have been put an end to by the loss of the ring through a fire.

3. *Acid Esters of Methyl Succinic Acids.* *By* Professor J. J. SUDBOROUGH, *Ph.D., D.Sc., and* WILLIAM A. BONE, *Ph.D., D.Sc.*

The acid esters of mono-, di-, tri-, and tetra-methyl succinic acids have been prepared and their esterification constants and electric conductivities determined.

The results of the esterification constants clearly indicate the retarding influence which the introduction of methyl groups has on the rate of esterification of methyl hydrogen succinate. No broad generalisations can be drawn from a study of the electric conductivities.

The determination of the esterification constants of a pair of isomeric acid esters derived from an unsymmetrical dibasic acid would appear to be one of the best methods for ascertaining their constitutions. The following acid esters have been prepared:—Methyl hydrogen succinate, m.p. 58°. Methyl hydrogen methyl succinate, an oil identical with the compound described by Braunschweig. Although, theoretically, two isomeric monomethyl esters are possible, so far only one has been obtained. The same ester is formed when any one of the following methods is employed: (*a*) Partial esterification of the acid; (*b*) partial hydrolysis of the neutral ester; (*c*) addition of methyl alcohol to the acid anhydride. Methyl hydrogen *cis* dimethylsuccinate melting at 38°. Methyl hydrogen *trans* dimethylsuccinate melting at 47°·5. Two isomeric methyl hydrogen *gem* dimethylsuccinates melting at 40°·5 and 52°. Two isomeric methyl hydrogen trimethyl succinates, both of which are oils. Methyl hydrogen tetramethyl succinate, m.p. 68°.

4. *Compounds of Trinitrobenzene with Alkylated Arylamines.*
By H. Hibbert, *M.Sc., and* Professor J. J. Sudborough, *Ph.D., D.Sc.*

In continuation of the earlier work[1] it has been found that trinitrobenzene forms well-defined, stable additive compounds with the alkylated naphthylamines. These compounds are all of a reddish or reddish-black colour, and are decomposed when boiled with mineral acid.

The products formed from trinitrobenzene and secondary bases—for example, methyl α-naphthylamine and ethyl β-naphthylamine—may be acetylated and yield products which are identical with those obtained by the combination of trinitrobenzene with the acetylated secondary base. As a rule these acetyl derivatives are unstable, and when crystallised from different media decompose into their constituents—namely, trinitrobenzene and the acetylated base.

The compounds of trinitrobenzene with tertiary bases—for example, dimethyl α-naphthylamine and dimethyl β-naphthylamine—are unacted on by acetic anhydride, and may be boiled with this reagent for some time without undergoing decomposition.

The following compounds have been obtained:—

1. Ethyl α-naphthylamine trinitrobenzene, dark maroon-coloured needles, melting at 153–153°·5.
2. Diethyl α-naphthylamine trinitrobenzene, scarlet needles, melting at 95–95°·5.
3. Dimethyl α-naphthylamine trinitrobenzene, red needles, melting at 105–106°.
4. Ethyl β-naphthylamine trinitrobenzene, ruby-black prisms, melting at 106°; the acetyl derivative crystallises in very large sulphur-yellow prisms, melting at 77–78°.
5. Diethyl β-naphthylamine trinitrobenzene, short black prisms, melting at 115–116°.

5. *Action of Alkalis on Cinnamic Acid Dibromide and its Esters. By* Professor J. J. Sudborough, *Ph.D., D.Sc., and* K. J. Thompson, *B.Sc.*

By the action of alkalis on cinnamic acid dibromide and its esters a mixture of α-bromo-cinnamic and α-bromo*allo*-cinnamic acid is obtained. When the acid dibromide itself is employed the main product is the α-*allo*-acid and only a small amount of the α-acid. When however the esters are used, the two acids are formed in almost equal quantities. An increase in temperature, presence or absence of sunlight, and the nature of the alkali employed affect but very slightly the relative amounts of the two acids formed. Dimethyl aniline reacts with cinnamic acid dibromide yielding as chief products cinnamic acid, α-bromo-cinnamene, and a minute quantity of a brominated acid.

6. *On the Absorption of Ammonia from Water by Algæ.*
By Professor E. A. Letts, *Ph.D., and* Mr. J. S. Totton.

7. *On Determinations of Atmospheric Carbonic Anhydride made on Board the 'Discovery' on the Voyage to the Cape and thence to New Zealand. By* Professor E. H. Letts, *Ph.D.*

8. *A New Method of causing Isomerisation.*
By Professor Raphael Meldola, *F.R.S., V.P.C.S.*

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[1] *Journ. Chem. Soc.*, 1901, 79, 522.

9. *Interim Report on the Action of Gases dissolved in Metals and Alloys on their Properties.*

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10. *Report on the Nature of Alloys.*—See Reports, p. 175.

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11. *Report on Preparing a New Series of Wave-length Tables of the Spectra of the Elements.*—See Reports, p. 137.

SECTION C.—GEOLOGY.

PRESIDENT OF THE SECTION—Lieut.-Gen. C. A. MCMAHON, F.R.S., V.P.G.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

Rock Metamorphism.

I WISH to offer some observations to-day on some aspects of rock metamorphism; and as this is a complex subject, and the time at my disposal is brief, I purpose to deal with it in simple language, and to avoid as far as possible all petrological technicalities.

A short description of a granite in the Satlej Valley of the Himalayas will, I think, introduce us by a short cut to the consideration of 'contact metamorphism,' an important branch of the subject under consideration.

The granite I allude to is an intruder in the normal gneissose-granite of the Himalayas, and cuts through it at right angles to its foliation.

The intruder, which is some yards wide, did not rise through a simple crack or fissure, for its passage upwards was interrupted by a sheet of dark intrusive diorite, older than itself, which ran, roughly speaking, parallel to the foliation of the gneissose-granite.

This sheet of diorite offered considerable resistance to the rising granite.

The granite zigzagged backwards and forwards across the diorite and ran along its edges for fifty yards or more, converting it into a mica trap.

It then tore itself away and continued its upward course. The granite I am describing was in a molten or fluid condition at the time of its eruption, as I hope to show in my subsequent remarks.

I may pause here, however, to consider in passing what was the probable temperature reached by a granite such as that above described.

The question is one of very great difficulty, as we know so little about the plutonic conditions of igneous rocks, and can only arrive at an answer to our question by indirect evidence.

The melting-point of quartz ranges from 1425° to 1450° C., but the fusion point of granite need not necessarily be as high as this, inasmuch as the presence of water at high temperature materially lowers the melting or solution point.

The fusion point of the other constituents of granite may here be mentioned: that of orthoclase ranges from 1164° to 1168°; microcline, 1169°; albite, 1172°; augite and hornblende, 1188° to 1200°; apatite, 1221°. Zircon, which is commonly found in granites, and is one of the first minerals to separate out of the magma, is shown by Ralph Cusack to have probably a melting-point of 1760°; whilst topaz, a not uncommon mineral in granite, is infusible up to the melting-point of platinum, namely, 1770° C.

If we consider, therefore, the melting-points of the mineral constituents of granite, we can hardly avoid the conclusion that for the magma to have attained perfect fluidity it must have reached a temperature of at least 1200° C.

Vernadsky has shown that kyanite is transformed into sillimanite, a well-known product of contact-metamorphism at a temperature of 1320° to 1380°.

If rocks in contact with granitic masses have been raised to this temperature, it follows that the granite itself must have been still more heated. Vernadsky's observations have been relied on by Mr. George Barrow in his well-known paper 'On an Intrusion of Muscovite-biotite Gneiss' in the S.E. Highlands of Scotland to account for the presence of sillimanite in the inner zone of metamorphism between the kyanite schists and the granite, and he considered that the temperature attained by the 'central masses of the Highland rocks' was probably higher than the figures indicated by Vernadsky.

Bearing all considerations in mind, including the influence of water and alkali in reducing, and of pressure in raising, the melting point, I think we may safely infer that granites, such as the Himalayan granite alluded to above, must have been raised at plutonic depth to a temperature midway between red and white heat, that is to say, to at least 1200° C.

To return to the granite of the Satlej Valley under consideration, I wish to draw attention to its condition just before crystallisation commenced.

A study of the mineral beryl will, it seems to me, throw light on this point.

Beryl is an important accessory mineral of the granite under description. It is clearly an original mineral, and it is material to note that it was the first mineral to crystallise out of the magma of the Satlej granite. This is shown by several circumstances.

In the first place the beryl preserved its perfect crystallographic shape, showing that its molecules during the entire period of crystallisation possessed comparative freedom of motion, and were not interfered with or molested by other solid minerals. In the second place all the essential minerals of the granite when they subsequently crystallised out of the magma were deposited on the crystals of beryl. I have specimens of the granite showing crystals of beryl enclosed in felspar, in muscovite, and in quartz.

The beryl, therefore, having been the first mineral to crystallise, the examination of thin slices of it under the microscope ought to give us a clue to the condition of the magma at the time the beryl was formed.

I have made such an examination, and I find that the beryl is crowded with liquid and gas cavities, the former containing movable bubbles and deposited crystals as well as water.

The bubbles are of substantial size relative to the area of the cavities, showing that the water suffered considerable contraction after it was sealed up in the beryl.

Scrope long ago suggested that the fluidity of lavas below the melting-point was due chiefly to the water they contained, and attributed the liquidity of granite to the same cause.

Scrope, however, in ascribing the mobility of an igneous rock to the presence of water seems to have had regard principally or wholly to its mechanical action in furnishing an elastic medium in the interstices between the crystals or grains of the rock. He observes that a lava consists 'of more or less granular or crystalline matter, containing minute quantities of either red-hot water, or steam in a state of extreme condensation, and consequent tension, disseminated interstitially among the crystals or granules, so as to communicate a certain mobility to them, and an imperfect liquidity to the compound itself,' and he quotes Scheerer and Delesse, both of whom assert that water exists in mechanical combination with all crystalline rocks, 'its minute molecules being intercalated between the crystals.'

Nowadays one would attribute the liquidity of an igneous rock not so much to the mechanical action of the water present in it as to the combination of the water with the mineral contents of the lava, producing a state of solution.

Sorby's investigations supported Scrope's observations, for he proved that the liquid contained in the inclusions in granite is water, and showed that it was caught up during the formation of the crystals, 'and was not introduced subsequent to the consolidation of the rock.'

The water now contained in cavities in the beryl was probably held in solution by the constituents of that mineral at the time of its formation, and as it cooled down the water separated from the substance of the beryl and formed the cavities in which we now find it imprisoned.

If this be so, it follows that when the beryl crystallised out of the magma, the latter was in a fluid condition, and held a considerable amount of heated water in solution. The temperature of the magma must have been above that of red heat, and the potential energy of the water held in a fluid state by pressure must have been great. When therefore in the course of the earth movements which accompany or in some cases are caused by the intrusion of eruptive igneous masses, pressure was temporarily relieved by the rupture and faulting of rocks, the superheated water contained in the magma would be ready to flash into steam with almost explosive violence.

It must also be borne in mind that water under great pressure, at or above a red heat, has a powerfully solvent action on most minerals, even on so refractory a mineral as quartz. When therefore granite in the molten and fluid condition of the Satlej granite was erupted along a line of faulting, fissure, or weakness, the superheated water or steam, bearing with it much mineral matter in solution, must have acted with great chemical energy on the rocks into which it was intruded.

I have spoken of water carrying mineral matter in solution, and of a magma carrying water in solution. These two conditions may rapidly succeed each other under varying conditions of temperature and pressure. To use the words of Van Hise, 'under sufficient pressure and at a high temperature there are all gradations between heated waters containing mineral material in solution and a magma containing water in solution.'

The condition of the beryl crystals, crowded as they are with liquid cavities, shows how high a proportion of superheated water was contained in the fluid granite magma at the time of their formation.

Sorby estimated that the fluid cavities in the quartz of granites sometimes amount to more than ten thousand millions to the cubic inch. As quartz, however, is usually the last mineral of a granite to consolidate, it may be thought that the water contained in it is a residuum left by the felspar and muscovite on their separation from the magma; but the case of the beryl above quoted shows clearly that the amount of water diffused through the magma before the mica, felspar, and quartz began to consolidate must have been very considerable. The amount of water held in solution by a granite, during the time of its aqueo-igneous fusion, cannot be estimated by the amount of water given in the analysis of consolidated and dried hand-specimens of that rock. A considerable proportion of this liquid must necessarily have been lost during the gradual cooling of the rock, and in the course of its intrusion into neighbouring sedimentary strata as sheets, dykes, and veins. Sorby, as the result of other lines of investigation, came to the conclusion that the amount of water present in granite, though limited, is considerable.

We must now turn for a few minutes to consider the important question of the porosity of minerals, and their permeability by heated water and gas at high pressure.

The fact that solid substances are built up of molecules having interstitial spaces between them hardly needs demonstration nowadays.

But have we all quite realised that the molecules of rock-forming minerals and crystals are not inert particles of matter, but that they vibrate or revolve or are endowed with other orderly movement that may be likened to the motion of the planets round the sun?

Far, far away in space the solar system would, to an eye formed like our own, in all probability present a nebulous appearance, because the eye would not be able to see the individual members of our system.

So, too, the molecules of which crystals are built up may have their appropriate motions, but we cannot see them with the eyes of sense because the molecules are beyond the highest powers of the microscope.

We can, however, I think, perceive them with the eye of the scientific imagination; and the hypothesis that the molecules of minerals are separated from each other by intermolecular spaces, and have their modes of motion, seems essential to the comprehension of rock metamorphism.

The important experiments of Sir W. Roberts-Austen on the diffusion of gold in pure lead throw considerable light on this subject.

Disks of solid gold were held against the bases of cylinders of lead by clamps, and were kept in an upright position at the ordinary temperature for four years. At the end of this time it was found that the gold had diffused upwards in the solid lead, for a distance of 7·65 mm., in sufficient quantity to be detected by the ordinary methods adopted by assayers. Traces of gold were found still higher.

When a column of molten lead, 16 cm. high, was placed above solid gold and kept at a mean temperature of 492° C., that is to say, at 166° above the melting point of lead, but 569·7° below that of gold, the gold diffused in considerable amount, to the top of the lead column, in a single day.

Sir W. Roberts-Austen's experiments, above alluded to, demonstrate that even such metals as gold, whose melting point is as high as 1061·7° C., exhibit a measurable amount of kinetic energy at the ordinary temperature and pressure. Great results may no doubt be brought about at ordinary temperatures and pressures, when time, as in the laboratory of nature, is practically unlimited; nevertheless the importance of high temperature and high pressure, in operations connected with metamorphism, can hardly be overrated.

Not only does a rise in temperature increase the energy of the chemical actions and reactions which produce the mineralogical changes embraced by the term metamorphism, but it increases the porosity of minerals and facilitates the passage of liquids and gases through their pores.

The cohesion of molecules is lessened, the amplitudes of their vibrations, rotatory or other movements, are increased, and a passage is opened for the advance of chemical materials into the heart of the crystal.

Increase of temperature thus not only throws open the doors of the mineral fortress attacked, but gives enhanced energy to the invaders. The fact that the mineral components of a rock are, under conditions of heat and pressure practically porous to heated water, laden with chemical reagents in solution, is frequently brought home to the mind of the petrologist in a very tangible way. We sometimes observe, for instance, that metamorphic changes begin at the heart of a crystal, and leave the peripheral portions of it fresh and unaltered.

In such cases the chemical agents of change have evidently passed freely through the outer parts of the crystal, and have by preference selected its internal parts for attack.

In order to explain clearly how this remarkable result takes place, in the cases referred to, it will be necessary to diverge for a few minutes to consider another branch of our subject. It is difficult, if not impossible, to lay down any hard and fast rule of universal application, because the conditions under which igneous rocks crystallise vary with temperature, pressure, the relative proportion of constituents, and other local causes, and these variations in the conditions may materially affect the results; but I think the rule that minerals crystallise out of a molten magma in the order of their basicity is of very frequent if not of absolutely general application. This rule also governs the growth of individual crystals, especially those that exhibit what is known as zonal structure. Take, for instance, the felspars of an igneous rock. A gradual passage may frequently be traced by the petrologist from one species of felspar at the heart of a crystal to another distinct species at its periphery. Sometimes a crystal is made up of more than two species, which shade more or less gradually into each other. In accordance with the rule laid down above, the more basic species formed first; then, as the percentage of the bases left in the magma gradually decreased, owing to the first formed crystals having taken a lion's share of the available bases, the felspars that formed later became gradually more and more acid in composition. Thus a large felspar of slow and gradual growth may be composed of several zones, each zone being successively less basic and more acid than that upon which it crystallised, each successive zone thus possessing slightly different physical properties from the one that formed before it. These statements are capable of roof. When sections of felspar, such as occur in thin slices of igneous rock, are xamined under the microscope in polarised light, petrologists can distinguish one pecies from the other—when the direction in which the sections were cut is pproximately known—by measuring the angles at which they extinguish from he twinning or the pinacoidal plane.

This is not mere theory. Each species of felspar has its own angle of xtinction and its own index of refraction. The determination of these two actors enables a petrologist to prove optically the change in composition; or, in ther words, the change in species which has taken place in the successive ones, during the gradual growth of a large zonal felspar.

Another general rule must now be mentioned. I think it may safely be sserted as a broad rule, that the different species of felspars are attackable by he chemical reagents which make themselves felt in metamorphic action, in the rder of their basicity; that is to say, the more basic felspars are more easily ttacked than the acid ones. When we bear in mind the facts stated above, we shall, I think, be able to see clearly how it is that the peripheral portions f large felspars in igneous rocks sometimes escape alteration, whilst the cores f these crystals are converted into secondary minerals, such as chlorite, silvery mica, zoisite, epidote, kaolin, steatite, saussurite, calcite, and scapolite.

The chemical reagents flowing in solution through the pores of the felspars, pass by the more acid and refractory species, and devote their energies to the more susceptible basic species entombed at the heart of the zonal crystals.

The point I wish to enforce most strongly is that the phenomenon above described, namely, the formation of secondary metamorphic minerals in the interior of a crystal, combined with the comparative immunity to change of the external portions, shows that the agents which brought about chemical changes at the core of the crystal flowed freely through its unaltered peripheral portions.

But some may ask whether the chemical agents referred to may not have gained access to the heart of a crystal by a crack. I answer that a crack is a coarse and tangible object that looms large under the microscope. A crack in a mineral liable to metamorphic action, through which chemical reagents have flowed, could not escape detection. The finest crack through a homogeneous mineral, such as, for instance, an olivine, can be readily seen, not only by the small canal worn by the corrosive action of the chemical agents that flowed through it, but by the alteration set up in the mineral along the whole course of the canal.

I have a thin slice from a beautifully fresh olivine contained in one of the lavas of Vesuvius collected by myself. A volcanic explosion or other cause, operating after the crystallisation of the olivine, produced a very fine crack in the mineral through which water, charged with chemical reagents, subsequently flowed. The crack, though of microscopic width, is filled with serpentine, and on both margins fibrous serpentine has been formed at the expense of the parent olivine, and constitutes a fibrous band on both sides of the crack throughout its entire length, the direction of the fibres being at right angles to the crack.

The rest of the olivine is of virgin purity and polarises in the most brilliant colours, contrasting strongly with the serpentine.

In this case it is clear that the chemical reagents, though free to flow along the crack, had commenced to extend beyond its walls, encouraged thereto by the porosity of the olivine itself. But how different is this case from those in which the entrance of the chemical agents had not been facilitated by a crack. In the case above described, the chemical changes set up were limited to the borders of the crack, and even had they gradually extended in the course of time to the whole of the olivine, the original canal by which the chemical reagents had gained access to the crystal would have remained to tell its tale, and exhibit along its course the banks of iron oxide thrown down by the chemical navvies that had excavated it.

Cracks save time as roads and canals do, but they leave behind them evidence of their former existence. In order to understand fully how rocks and minerals are so completely open to the attacks of chemical reagents, which penetrate to and produce chemical and mineralogical changes at the very hearts of minerals, we must fully realise how completely porous rocks and minerals are, to the heated liquids which carry these reagents with them in solution. Heat, as before stated, not only increases chemical energy, but destroys more or less completely the cohesion between molecules, and increases the amplitude of the vibrations, or other motions of the molecules, and consequently facilitates the entrance of liquids and gases into the pores of minerals, and their complete permeation by these powerful agents of change. Thus far we have been chiefly concerned with some of the principles underlying the branch of our subject embraced by the term contact-metamorphism, which implies operations conducted at considerable depths below the surface of the ground, under conditions of heat and pressure.

We must now consider very briefly changes produced at or near the surface by the agency of water, or, as Bischof in his well-known work termed it, metamorphism in the 'wet way.'

No hard and fast line, however, can be drawn between the two classes of operations, as the one gradually shades by fine gradations into the other. At one end of the scale we have high pressure and high temperature, and a fluid igneous magma holding water in solution, above a red heat, and giving up heated water or vapour charged with salts to the rocks in contact with it.

Passing to the other end of the scale through diminishing temperatures and pressures, we reach a condition in which the water circulating through the rocks at ordinary pressure and temperature is more abundant in amount, and holds acids and salts in solution, capable of setting up important chemical reactions in the rocks and minerals to which it gains access.

In the case of surface operations, moreover, the metamorphic agents—water, acids, salts—are being constantly renewed. Conditions differing as widely as the conditions at the extreme ends of our scale do not yield, however, precisely the same results. In both metamorphic change goes on with more or less briskness, but the products are different. Some minerals require great heat and great pressure for their production, and such minerals are never formed by any surface process of weathering. For instance, the temperature reached determines whether titanium dioxide crystallises as rutile, or in one of its other two forms, rutile requiring a temperature of over 1000° C., and being the only form of titanium dioxide 'stable at a high temperature.'

Temperature also seems to determine whether the silicate of alumina crystallises as andalusite, kyanite, or sillimanite, the two former being transformed into the latter, at a temperature of 1320° C. to 1380° C.

On the other hand some minerals require little heat for their formation, and are readily produced by metamorphic changes in the 'wet way.'

There seems to be some correspondence between the melting point of minerals and their density; thus in the case of eleven minerals produced by contact-metamorphism, whose average specific gravity ranges from 3·06 to 4·03, I find that their melting-point ranges from 954° to above 1770° C., high temperature and high pressure (a concomitant of plutonic conditions) appearing to be factors in the production of high specific gravity in minerals.

The genesis of individual species of minerals is a fascinating study, but the subject is too large to enter upon here.

Water gains access to rocks in several ways. It falls as rain; it rises from hidden depths; it leaks from the sea into horizontal beds or into strata dipping away from it; and it penetrates through faults and fissures. Rain in its descent takes up from the air oxygen, nitrogen, carbonic acid, and in some cases small amounts of nitric acid.

It is thus in itself a powerful solvent and potent agent in producing chemical change.

In its passage through the surface soil it dissolves humic and other organic acids, the products of vegetable decay, which add greatly to its solvent power and enable it to break up many silicates and to dissolve even silica.

By the time the rain-water reaches the solid rocks below the surface soil, it has become a very active agent in producing chemical change in them. It is by such agents, persistently applied during long periods of time, that large areas of ultrabasic igneous rocks have been altered into serpentine.

Hot springs are a well-known instance of water rising in considerable quantity from plutonic depths. They are known to occur in the plains of India, and are especially abundant in the Himalayas. I visited two very interesting ones at Suni, in the bed of the Satlej River, west of Simla. These springs rise apparently under the very bed of the river, and come to the surface on both banks within a yard or two of the rushing water of the Satlej. When I visited the springs they had a temperature of 130° F., and contrasted strongly with the cold water of the river flowing past them, which had descended from high Himalayan glaciers and had a temperature of 49° F.

The native inhabitants of neighbouring villages told me that the hot springs always appear at the very edge of the river, whatever may be the height of its waters during drought or flood. This statement is probably true, for I think the springs well up from below through the walls of a fault that traverses the bed of the Satlej at a high angle to its course, and the springs thus come to the surface on both its banks.

The metamorphic influence of these springs on the rocks in this locality has been very powerful. The ancient volcanic rocks there exposed have, for some distance up the river, been altered by aqueous agents almost out of recognition. The original structural characters of these lavas have been almost completely broken down and an amorphous substance substituted for the crystals and minerals of which they were originally composed.

This result shows that the crystals and minerals of these old lavas must, for all practical purposes, have been completely porous to the aqueous agents brought to bear on them.

The general transmutation of one mineral into another by the action of heated water holding mineral agents in solution, aided by heat and pressure, may take place in a variety of ways. Some of these processes are simple, but others are highly complex. Many are the results of a single operation, others of a series of changes, some of which prepare the way for those that follow.

In some cases the change may be brought about by the removal, in whole or in part, of one or more of the essential constituents of a mineral, whereby the relative proportions and mutual relations of those that remain are altered, as the following examples will show.

By loss of water limonite passes into hæmatite, and opal into crystalline quartz. Dyscrasite, by loss of antimony, passes into native silver, and pyroxene, by the removal of its lime and iron, is changed into talc. Simple oxidation or the absorption of oxygen by a mineral is responsible for another class of changes, as in the conversion of zinc blende into goslarite, and antimony into valentinite.

The loss of one or more of the ingredients, concurrently with the introduction of one or more new ones, causes many metamorphic changes, as in the conversion of marcasite into magnetite, of witherite into barite, and of azurite into malachite.

The well-known conversion of a peridotite into serpentine is a case in point. Here, part of the iron and magnesia is removed from the olivine, and water is introduced. A simple process like this, brought about by the percolation of surface waters through an igneous rock, is sufficient to transform considerable areas of rock masses into serpentine, as has been the case in parts of Cornwall.

Some metamorphic processes are more complex than those alluded to above, but Nature has unlimited time at her disposal, and is able to manufacture potent chemical reagents as her processes proceed. For instance, the sulphides of various metals of common occurrence in rocks, most of which, with the exception of those of the alkaline metals, are insoluble in water, by taking up oxygen pass into sulphates, most of which are soluble in that liquid at the ordinary temperature.

These sulphates are readily carried away in solution, and become potent factors of change in rocks through which water charged with these salts flows. Again, carbon dioxide, so abundant in percolating water, decomposes minerals containing lime or alkali, and removes them as soluble carbonates to effect powerful chemical reactions elsewhere.

I must pass over the subjects of paramorphism and pseudo-morphism, as the limited time at my disposal does not permit me to enter upon these subjects.

In the above sketch I have contented myself with a brief discussion of some of the leading principles that seem to me to underlie contact action and metamorphism in the wet way, because I venture to think that, if we really understand these two divisions of our inquiry, it will be unnecessary on the present occasion to enlarge on other branches of our subject.

Take, for instance, what is commonly called dynamic metamorphism. The main factors in this kind of metamorphism are the folding, crumpling, crushing, and shearing of rocks by earth movements, especially during the upheaval of mountains.

But these dynamic forces are potent factors in the development of heat.

In the case, therefore, of dynamic metamorphism, as in contact metamorphism, pressure and heat are the main factors acting in conjunction with the water shut up in or circulating through a rock. If we understand how these factors operate and produce the results we see in cases of contact metamorphism, we shall not fail to understand their action in a case of dynamic metamorphism.

These observations also apply to regional metamorphism; that is to say, to metamorphism produced in rocks at great depth, by being brought within the influence of the interior heat of the earth. The action of heat in increasing molecular motion and kinetic energy is well understood nowadays, and so long as we get heat it seems to me immaterial how heat is generated in rocks subject to metamorphic action.

In the above sketch I have intentionally omitted to enter into the details of chemical and mineralogical action that has brought about individual cases of metamorphic change.

Volumes would be required to do justice to so complex a subject, and the details would, in an opening Address, be out of place.

In conclusion I have, I trust, shown how important a part water plays as an agent of metamorphism, not only at and near the surface of the earth, but at plutonic depths. We have seen that the molten granite of the Satlej Valley, which was given as an illustration of a fluid igneous magma, contained a considerable proportion of water held in solution at considerably above red heat, and that the fluidity of the magma was due to its presence. We also saw that the great heat to which the magma was raised increased the potential energy of the contained water when a relief of pressure opened the way for the intrusion of the molten magma into neighbouring rocks. We also saw that this water was rendered by heat a powerful solvent, and that it carried with it into the adjoining rocks the mineral matter of the granite in solution. We also saw that heat increased the porosity of minerals, facilitated the passage of liquids laden with mineral matter through their pores, and increased the potency of chemical action.

The following Papers and Reports were read:—

1. *The Geology of the Country in the Neighbourhood of Belfast.*
By Professor GRENVILLE A. J. COLE, *F.G.S.*

Belfast stands between the lava-plateaux of Cainozoic age in Antrim and the undulating surface of Silurian rocks in Co. Down. The special interest of the district lies in the preservation of Mesozoic rocks, which elsewhere are scarcely represented in Ireland. Schists and gneisses in the north-east of Co. Antrim possibly represent Archæan masses refolded during the Caledonian earth-movements. The Caledonian folds gave us the crumpled county of Down, and admitted the granite of Newry and Castlewellan along an axis running north-east and south-west. Both Ordovician and 'Upper Silurian' (or Gotlandian) strata are represented in this area. The conglomerate of Cushendun is probably of Old Red Sandstone age; but the Carboniferous Limestone, which is so marked a feature of Ireland as a whole, plays only a small part in the north-eastern counties. The

Carboniferous strata of Ballycastle, west of Fair Head, are mainly sandstones with intercalated coal-seams, on the same horizon as the Calciferous Sandstone of the South of Scotland.

A patch of marine Permian strata occurs east of Belfast, at Holywood; and the British type of Trias, red rocks with salt and gypsum, is well represented under the basalt capping that has preserved it. The Rhætic sea spread into this area, and terminated far west against the Londonderry highlands; the Lias also began to form, and is now finely exposed at Waterloo, close to Larne. It is questionable if higher Jurassic beds than those now left to us were ever laid down in this region; elevation and denudation certainly set in early, and the country remained dry land until the middle of Cretaceous times. Then, in the westernmost extension of the great Chalk sea, the sands, conglomerates, and white limestone of Antrim were deposited, representing the Upper Cretaceous of England in a thickness of about 100 feet. The cliffs of hardened chalk, between red basement-beds of Trias and the black basalt scarp above, form, in Glenariff and Murlough Bay, one of the most beautiful contrasts in our islands. It is clear that in early Eocene times both the counties of Antrim and Down were covered with a rolling series of chalk uplands, resembling on a less massive scale our present Salisbury Plain. This quiet and newly upheaved country was destined to be devastated by volcanic action, more continuous and extensive than had been seen in the British Isles since Old Red Sandstone times.

The ground was first broken by rifts running from south-east to north-west, and these were quickly filled by basic lavas. Flow after flow emerged across the country, filling up the hollows carved by denudation, and forming in time continuous plateaux. Although a few explosive vents were established here and there, fluid basalt was the great feature of these eruptions. A time of quiet followed, when the lake-deposits and iron ores of Glenarm, Ballypalady, &c., were accumulated; and sporadic outbreaks of rhyolite appeared, the most prominent being that of Tardree Mountain. Then the basic eruptions were renewed, and the columnar basalts of the Causeway coast belong to this second epoch of activity.

Mr. Starkie Gardner has referred these volcanic masses of Northern Ireland to early Eocene times, from a study of the plant-remains in the associated lake-deposits. Hence we find the marine Cretaceous beds followed by a terrestrial and igneous Eocene; and possibly some of the latest vents were active in Oligocene times. Thenceforward we know nothing of Irish geological history until the glacial epoch, which has left such piles of boulder-clay and gravel across the country. The latest feature of interest is the blue marine clay of Belfast and Magheramorne, full of exquisitely preserved post-Pliocene fossils. This lies unconformably on the glacial drift, and represents a comparatively recent submergence and re-elevation. The raised beach of Larne, with flint-chips in it prepared by man, indicates the modern date of the movements of elevation.

When we go south from the immediate neighbourhood of Belfast, the Mourne Mountains rise conspicuously, their summits being far more bold than those of the adjacent Caledonian granite ridge. They are also formed of granite, which cuts across basic masses; the latter are seen at Carlingford to be at any rate post-Carboniferous. In turn, a few basic dykes of still later date traverse the granite. By its relation to these two basaltic series, and its petrographic identity with the Cainozoic granites of Mull and Skye, we need not hesitate to regard the Mourne granite as of Eocene age. It forms, then, as Mr. McHenry has pointed out, an interesting deep-seated mass for comparison with the rhyolitic lavas of the inter-basaltic epoch in Co. Antrim.

From the above notes, which have no claim to originality, it will perhaps be seen how attractive the Belfast area is to geologists, by reason of its very contrast with the accepted types of Jurassic, Cretaceous, and Cainozoic deposits, as known to us in the London Basin. Those familiar, on the other hand, with the geology of the Scottish Isles, will find many interesting points of similarity.

2. *On the Marine Fauna of the Boulder Clay.*
By JOSEPH WRIGHT, *F.G.S.*

The author has examined microscopically 112 samples of boulder clay from various places in the British Isles and in Canada: forty-seven of these were from Ireland, twenty-seven from England and Wales, twenty-two from Scotland, one from the Isle of Man, and fourteen from Canada. In seventy-one of the British and in nine of the Canadian samples foraminifera were found; the specimens of the clays had been taken from various altitudes, some few of them from localities over 1,000 feet above the sea. Almost all the forms found are referable to species which at present live at moderate depths off our coast, and most of them have the fresh appearance of these species. *Nonionina depressula* is often met with in great profusion, fully one half of the entire specimens found being referable to this species. One hundred and thirteen species have been found in the clays of Ireland, seventy-two in those of the Isle of Man, sixty-five in England and Wales, forty in Scotland, and fifteen in Canada.

In thirty-one of the gatherings no foraminifera were met with, whilst in some of the others they were very rare. The absence or the scarcity of specimens in some of the samples may be due, in part at least, to the circumstances that it was only the first floatings from the clays that were examined, and also that these minute organisms are liable at times to be overlooked when the material is being examined. To ascertain how far floatings could be relied on for giving conclusive results, 1 oz. troy of the boulder clay from Woodburn, near Carrickfergus, was examined with the utmost care. The first floating was found to contain 1,400 specimens, the floating process being repeated twenty-five times before specimens ceased to come up; upwards of 600 additional specimens were thus obtained. What remained of the clay was then examined in detail with the microscope, and sixty-seven more specimens were got from it.

In the boulder clay at Knock Glen, near Belfast, seventy-nine species were obtained, many of them being very rare forms, six being only known as recent British species from collections on the west coast of Ireland, two of these also occurring off the west coast of Scotland. The presence of these microzoa would lead us to infer that the clay at this place was probably deposited in deep water, when the land stood at a much lower level than at present, and when the marine conditions must have been somewhat similar to those now prevailing off the west coast of Ireland.

3. *Report on the Exploration of Irish Caves.*—See Reports, p. 247.

4. *On the Middle Cambrian Trilobites, &c., of Mount Stephen, British Columbia.* *By* DR. HENRY WOODWARD, *F.R.S.*

5. *Preliminary List of the Minerals occurring in Ireland.*
By HENRY J. SEYMOUR, *B.A.*

The following list of minerals, which is only of a preliminary nature, comprises all the species which the writer has up to the present satisfied himself undoubtedly occur in Ireland. In compiling it several public and private collections of minerals were examined, but a few more have still to be worked over before the list can be regarded as including all the species which are to be found in this country. It is intended to ultimately publish in the 'Proceedings of the Royal Irish Academy' the completed list, together with full details regarding the locality, mode of occurrence, and some other points of interest connected with each species.

Graphite.
Sulphur.
Gold.
Silver.
Copper.
Stibnite.
Molybdenite.
Galena.
Chalcocite.
Blende.
Pyrrhotite.
Bornite.
Chalcopyrite.
Pyrites.
Cobaltite.
Marcasite.
Mispickel.
Tetrahedrite.
Geocronite.
Halite.
Fluor.
Quartz.
Tridymite.
Opal.
Water.
Cuprite.
Corundum.
Hæmatite.
Ilmenite.
Magnetite.
Cassiterite.
Rutile.
Octahedrite.
Brookite.
Pyrolusite.
Manganite.
Limonite.
Bauxite.
Psilomelane.
Calcite.
Dolomite.
Siderite.
Aragonite.
Smithsonite.
Cerussite.
Malachite.
Azurite.
Orthoclase.
Microcline.
Anorthoclase.
Albite.
Oligoclase.
Andesine.
Labradorite.
Anorthite.
Enstatite.
Hypersthene.
Augite.
Spodumene.
Wollastonite.
Rhodonite.
Hornblende.
Arfvedsonite.
Beryl.
Iolite.
Garnet.
Olivine.
Fayalite.
Idocrase.
Zircon.
Topaz.
Andalusite.
Sillimanite.
Kyanite.
Gadolinite.
Zoisite.
Epidote.
Axinite.
Calamine.
Tourmaline.
Staurolite.
Apophyllite.
Heulandite.
Epistilbite.
Phillipsite.
Harmotome.
Stilbite.
Laumonite.
Chabazite.
Gmelinite.
Levyne.
Analcite.
Natrolite.
Scolecite.
Mesolite.
Thomsonite.
Muscovite.
Biotite.
Lepidomelane.
Serpentine.
Talc.
Glauconite.
Kaolinite.
Pyrophyllite.
Sphene.
Apatite.
Pyromorphite.
Vivianite.
Erythrite.
Wavellite.
Beudantite.
Barytes.
Anglesite.
Gypsum.
Amber.

A number of other species (about twenty-two), which have been recorded by more or less competent authorities, are not inserted in the foregoing list, as there appears to be some doubt at present as to their correct determination, and because specimens of many of them cannot now be found in any museum or private collection.

6. *On the Tusks and Skull of* Mastodon angustidens.
By C. W. ANDREWS, *D.Sc.*

7. *Report on the Registration of all Type Specimens of British Fossils.*
See Reports, p. 210.

8. *Notes on the Fossils of the Silurian Area of N.E. Ireland.*[1]
By R. CLARK.

It would be difficult, after the closest investigation, to add much to the exhaustive list of species given in the excellent paper on this subject which was read by Mr. Swanston before the Belfast Naturalists' Field Club some twenty-five years ago.

In that paper reference is made to the classification by the Geological Survey of the rocks of the district, under the general heading of Lower Silurian.

Subsequent to the publication of the maps of the area the information as to the Silurian fauna was greatly extended by the labours of Professor Lapworth and Mr. Swanston, to whom science is so largely indebted. The completion of the 1-inch geological map of Ireland enabled the revision of work done in the earlier stages of the Survey's existence to be undertaken, and in this revision the N.E. Silurians were among the first dealt with.

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[1] Communicated by permission of the Director of the Geological Survey.

The work was proceeded with until not only the N.E. area, but the southern Silurian districts also were gone over. A comparison of the old series of maps and the revised editions published within the last few years shows that the collections made have necessitated very considerable alterations in the original mapping.

Taking Coalpit Bay, Donaghadee, as a starting-point, this prolific though circumscribed little area afforded a key to the vast proportion of the Silurian beds, which with slight interruption extend southwards to the Atlantic on the Waterford coast; and although in few other localities was the same wealth of fauna of different horizons met with, it was interesting to recognise in numerous new localities the occurrence of forms which enabled a ready recognition of the exact position of the beds, most of which were typically represented in the regular sequence of Coalpit Bay.

In the district covered by Mr. Swanston's paper it will be sufficient to mention a couple of localities new or hitherto unreferred to. First, a section cut through by a small stream at Lessan, near Saintfield, '1,' sheet 37, from which a number of specimens, indicative of Lower Hartfell (Caradoc) beds, were obtained. Amongst other species were the following:—

Diplograptus foliaceus.
„ *mucronatus.*
„ *truncatus.*
Climacograptus scharenbergi.
Leptograptus flaccidus.
Pleurograptus linearis.
Glossograptus hincksii.

Dicellograptus elegans.
„ *forchammeri.*
„ *morrisi.*
„ *moffatensis.*
Dicranograptus ramosus.
Corynoides calcularis.
Siphontreta miculæ.

The second Locality is a small quarry in Holywood Glen, '1,' sheet 29, which yielded a number of species characterising this locality as the Glenkiln horizon (Upper Llandeilo). Amongst the forms which occur here in easily recognisable condition are—

Cœnograptus gracilis.
„ *surcularis.*
„ *pertenuis.*
Thamnograptus typhus.
Glossograptus hincksii.
Climacograptus scharenbergi.
„ *bicornis.*

Dicellograptus intortus.
„ *sextans.*
„ *moffatensis.*
Dicranograptus ramosus.

The absence of *Rastrites maximus*, *Dicellograptus anceps*, and *Pleurograptus linearis* having been commented on by Messrs. Swanston and Lapworth, it is satisfactory to record that these forms I have since found, the first named at Tieveshilly, the second in a pocket of black slate in greenish mudstone at Coalpit Bay, whilst *Pleurograptus linearis* was collected from the locality at Lessan, previously referred to.

A unique specimen from the Lower Birkhill (Llandovery) beds of Coalpit Bay claims attention. It has been identified by Mr. E. T. Newton as *Berwynia carruthersi*, a lycopodiaceous plant first described by Professor Hicks as occurring at Pen y Glog Slate Quarry, North Wales.[1] It has not hitherto been recognised in Ireland.

Passing from what may be styled the Belfast immediate area towards the south and south-west, some ten additional fossiliferous localities were added to those already recorded from the district comprised within '1,' sheet 48. They were with one exception all indicative of the Middle or Lower Birkhill horizons, and save from one locality, Lough Erne, on the N.E. margin, which yielded eight species of Graptolitidæ, the specimens obtained were not well preserved.

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[1] *Quart. Jour. Geol. Soc.*, vol. xxxviii. p. 97.

The Armagh district, '1,' sheet 47, afforded good and interesting collecting grounds, though no fossils from the Silurian beds appear to have been previously recorded. A close examination disclosed numerous localities in both upper and lower strata, ranging from Lower Llandovery to Upper Llandeilo, this latter zone being well represented a little north of Poyntzpass by the occurrence of—

Dicellograptus moffatensis.
  ,, *sextans.*
  ,, *forchameri.*
Didymograptus superstes.
Dicranograptus ziczac.
Diplograptus bimucronatus.
Cœnograptus gracilis.
Climacograptus scharenbergi.
Siphontreta miculæ.

These forms were found in the black carbonaceous cherty band generally associated with this particular horizon.

'1,' sheet 69, afforded substantial additions to the list already published therefrom. Graptolites were procured from some twelve additional localities, and from many of these the specimens were obtained in excellent preservation; in this respect those from Killyrue, four miles S.E. of Cootehill, are specially worthy of mention.

The known localities for Silurian fossils on '1,' sheet 80, have been much increased, and good specimens obtained of Lower Caradoc and Llandovery species. Of the former *Diplograptus foliaceus*, *Dicellograptus*, and *Pleurograptus* were indicated, whilst the higher zone is distinguished by such as *Monograptus convolutus* and *Monograptus tenuis*, as also *Diplograptus foliaceus* or *palmeus*, which is somewhat rare outside Coalpit Bay district.

The fossils of the Silurian rocks of '1,' sheet 81, are dealt with rather fully in the memoirs of that and the adjoining sheet 91. In the latter the beautiful district of Slane afforded a rich harvest of forms ranging from Llandeilo to Wenlock.

Sheet 82 has been hitherto regarded as a barren area so far as fossils were concerned. However, a close search disclosed at a couple of localities near Clogher Head the existence of the zone of *Monograptus exiguus* on top of Upper Llandovery, and in addition to *M. exiguus* beautifully preserved specimens of *Monograptus attenuatus*, *Crispus*, *proteus* and *lobiferus* were procured. At no other locality save Tieveshilly was the same peculiar group observed.

Having now reached the banks of the Boyne the north-eastern area may be considered as ended. Not so the Silurian beds and their fossils, which proved equally interesting and varied when traversed from the Boyne valley southwards to the coast of Wexford and Waterford.

9. *Note on the Occurrence of Bagshot Beds at Combe Pyne, near Lyme Regis.*[1]

By HORACE B. WOODWARD, *F.R.S.*

In the Summary of Progress of the Geological Survey for 1900, p. 122, Mr. Clement Reid remarked, 'it is probable that a chain of outliers of the Bagshot river-gravels will connect the Eocene of Dorset with that of Bovey Tracey in Devon.'

The cuttings on the new railway between Axminster and Lyme Regis have since displayed, in the neighbourhood of Combe Pyne Hill, at an elevation of about 400 feet, beds of fine white sand, white pipe-clay, and white, red, and mottled stony clays, with much rough flint and chert gravel. These beds have in places a marked inclination towards the east, due probably to original deposition, and in all respects they bear a close resemblance to the white and coloured clays and sands, and the coarse gravels, which border the Bovey basin at Wolborough and other places near Newton Abbot. They rest on a platform of Upper Greensand.

The beds at Wolborough I some years ago regarded as equivalent to the 'plateau drifts' of Haldon, but Mr. Reid has recently brought forward evidence to show that both are for the most part of Bagshot age, with the exception only of the deposits that have been rearranged in later times. There is, therefore, good reason for referring to the Bagshot series the beds at Combe Pyne, which are evidently *in situ*, and which possess so many of the features characteristic of that formation.[1]

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[1] Communicated by permission of the Director of the Geological Survey.

FRIDAY, SEPTEMBER 12.

The following Papers and Report were read:—

1. *On the Viscous Fusion of Rock-forming Minerals.* *By* J. JOLY, *F.R.S.*

In a paper read at the Congrès Géologique International of 1900, and in a short note communicated to the British Association Meeting at Bradford, 1900, experiments on the viscous fusion of some rock-forming minerals are described by the author. It appeared that under the influence of prolonged exposure to high temperatures, rounding and other signs of fusion (a breakdown of stability as a solid) could be obtained at much lower temperatures than have hitherto been assigned as the melting-points. This lowering of the melting-point under prolonged heating (four hours) is more marked generally in the case of minerals containing a large percentage of silica and most marked in the case of quartz. On this account the *order* of the melting-points is in general different under conditions of prolonged heating than under conditions of short exposure.

The former results, as regards melting under conditions of short exposure (results required for comparison with those obtained under conditions of long exposure) were not quite satisfactory (as at the time the author pointed out) in so far that the observations were not effected in the same manner as those under conditions of prolonged exposure. This defect in the observation has now been removed. One-minute exposures have been made of all the minerals previously dealt with on exposures of four hours, and the results confirm the former conclusions but reveal a decreased difference in the two melting-points; in other words, the short-exposure melting-points being below previous results, the *depression* of melting-point upon prolonged exposure is less than formerly deduced. The depression, however, increases generally with the silica-content of the mineral, as previously observed.

2. *The Drift Map of the Dublin Area.* *By* J. J. H. TEALL, *F.R.S.*

3. *Note on the Volcanic Rocks of Glencoe, and their Relation to the Granite of Ben Cruachan.* *By* HERBERT KYNASTON.

The mountainous district about Glencoe is known to be occupied by a large area of volcanic rocks. These are described briefly in the present communication, together with a small patch in the north-east part of the Blackmount Forest. Some account is also given of the behaviour and order of succession of the rocks, which are shown to closely resemble the phenomena observed in the Lower Old Red sandstone volcanic series of Lorne. The base of the series is well seen near the western end of Glencoe, where it rests upon an inclined surface of the older rocks, the slope of the older surface of deposition being to the east. The lower part of the series consists of about 1,500 feet of basic andesites, identical in character with those of Lorne. On the north side of the glen, above Loch Triochatan, conglomerates, sandstones, and shales occur below these andesites, and occasional thin intercalations of shales are found at higher horizons. Resting upon the basic andesites are rhyolitic lavas, followed by agglomerates and breccias, which are capped by about 700 feet of hornblende-andesites.

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[1] Particulars of the sections are given in the Summary of Progress of the Geological Survey for 1901, pp. 53–59 (1902).

The series has in Glencoe a general south-easterly dip, and the higher beds gradually overlap on to the older schists towards the eastern portion of the area. Thus, in the Blackmount the rhyolites rest immediately upon the schists, the surface of the older rocks being remarkably steep. During the author's recent work for the Geological Survey the age of these volcanic rocks has been definitely settled by the discovery of Lower Old Red plant remains in a bed of black shale at the base of the east face of the Buachaille Etive Mor. In this bed Messrs. Peach and Tait found specimens of Psilophyton and Pachytheca in June last. The associated lavas are therefore of the same age as those of Lorne.

In the Blackmount the volcanic rocks are cut and metamorphosed by the granite of the Clach Leathad, which is a continuation of that of Ben Cruachan to the south-west, and of that of the Moor of Rannoch to the north-east. Again, a large mass of granite, of Ben Cruachan type, is intrusive in the basic andesites on the south side of Glencoe, near Clachaig. Thus, these granite masses are of later date than the volcanic period of Lower Old Red Sandstone times. It should be mentioned in this connection that in the basement conglomerates on the north side of Glencoe well rounded boulders of hornblende-granite and diorite occur, and granite blocks have also been found in the breccias near Kingshouse. It is not possible, however, that these boulders could have been derived from the granitic masses now exposed in the same neighbourhood, as these have been conclusively shown to be of later age than the volcanic series.

The final phase of the igneous activity of the district was marked by the formation of numerous dykes of porphyrite and quartz-porphyry, which are seen to cut both the granites and the lavas.

4. *Notes on the New Geological Map of Victoria.* *By* JAMES STIRLING.

5. *On the Original Form of Sedimentary Deposits.*
By REV. J. F. BLAKE, *M.A., F.G.S.*

In determining the position and outline of ancient continents by observing the direction in which the sediment derived from them thickens or thins, and in interpreting the significance of the contours of the sea-bottom, it is necessary to consider what will be the actual shape as a whole of any sedimentary deposit of single origin in relation to the land whence it is derived.

It has been assumed by several authors, both of text-books and of special memoirs, that sedimentary deposits are thickest near their source of origin, and that limestones are deposited at great distances from the shore. The author gives reasons for taking a somewhat different view. The action of tides and currents is considered as a subsequent operation; the original form of the deposit would be that which would result from a river carrying detritus directly outwards into a tideless sea. The coarse material which is pushed along the bottom of a river fills up the angle between the lowest level the river reaches and the constantly deepening bottom of the sea, and the deposit is consequently wedge-shape towards the land and sharply sloping seawards, like the tip of a railway embankment. The detritus which floats consists of all that has too low a power of sinking to overcome the velocity of the stream, and only begins to sink on the retardation of that velocity. The detritus with any particular rate of sinking will thus descend faster and also be crowded into a narrower area at a distance from the shore, and so form a thicker deposit there, where alone there is permanently room for it. This result will be modified by (1) the expansion laterally of the retarded stream, (2) the evaporation of the surface-water, (3) the mixture with sea-water, (4) the superposition of various maxima at different distances from shore, (5) the redistribution by tides and currents.

During the continuance of constant physical conditions the seaward boundary of river-brought deposits will thus be a marked line—the 'mud-line' of Dr. Murray—at various depths, according to circumstances. At this line there is a rapid change of slope. This has been called an escarpment, and the edge of the continental plateau, but it is suggested that it is really the limit of terrigenous deposits in bulk.

The lateral expansion of the stream divides it into two spirals on the two sides of the axis and separated by it. Along this axis the deposit will be carried farther to sea than on the two sides. This will cause an apparent depression of the sea-bottom opposite the mouths of direct rivers. These depressions have been taken to be submerged river-channels, but they are the natural result of the form of the deposit, except in special cases—of which the Congo may be one. Such depressions may be seen indicated on charts of the sea opposite suitable rivers, as on the west coast of Spain and India, and on the east coast of America.

Original organically formed limestones require not only water free from sediment, which may be found between the openings of large rivers, but an abundant supply of the organisms producing them. It is seen from the results of the 'Challenger' expedition that 60 per cent. of the species of such animals, and probably a higher one of the specimens, inhabit the first 100 fathoms, and another 20 per cent. the next 100 fathoms. Limestones are therefore most likely to form narrow lenticles with the long axis parallel to the shore, as in the case of barrier reefs; and when we find them giving place to shales, it is not because we are approaching a shore-line, but because in going parallel to the shore-line we are approaching a source of sediment.

6. *Fossils from Cretaceous Strata in the Salt Range of India.* *By* Professor H. G. SEELEY, *F.R.S.*, *V.P.G.S.*

Hitherto there has been no evidence of cretaceous strata in the Salt Range of the North of India. But Mr. Ernest G. Fraser, formerly of the Punjab Civil Service, has found many species of the type or age of the Upper Greensand. In 1893 he crossed the Salt Range and made a collection, placed in my hands, in which are the usual Primary, Secondary, and Tertiary types indicated by Mr. Wynne. But in addition are typical Cretaceous species in limestone. Among the more abundant are *Spondylus costulatus* (Stol), *Spondylus calcaratus* (Forbes), *Hinnites andoorensis*, and *Lucina arcotina*. The specimens are in good preservation, and weathered out from the rock. They are from the shoulder of Sekasar. Mr. Fraser did not draw a section; but the fossils which are deposited in the Royal Indian Engineering College show that the section must have been similar to those given by Mr. A. B. Wynne, except that Mr. Fraser had the good fortune to find Cretaceous fossils below the Tertiary strata. This northward extension of the fossils suggests that the Indian Cretaceous sea may possibly have been continuous with that of Central Asia, though the beds described by Dr. F. Schmidt in Siberia have fossils of a Gault type which has not yet been recognised in the Salt Range of India.

7. *Investigations into the Glacial Drifts of the North-east of Ireland, conducted by the Belfast Naturalists' Field Club. By* Madame CHRISTEN.

8. *On the Brockrams of the Vale of Eden and the Evidence they afford of an inter-Permian Movement of the Pennine Faults. By* PERCY F. KENDALL, *F.G.S.*

The author has been engaged during occasional visits to the Vale of Eden in the study of the well-known Brockram conglomerates, which form so conspicuous an element in the Poikilitic series of the district. Tentative results obtained five or six years ago have been fully confirmed by later observations, and though the investigation is not quite complete, the author regards the present occasion as an opportune one for presenting a preliminary statement of views which have already obtained some currency by annual demonstrations in the field to scientific societies of the North of England.

The stratigraphical relations of the Brockrams can be well studied in the almost continuous sections which are exposed between Hoff Beck, two miles west of Appleby, and Brackenber Common, three miles east of the town. The beds dip to north-east at about twenty degrees, and the succession here exposed is as follows:—

St. Bees Sandstone (Trias):—

Permian.
6. Shales and Sandstones.
5. Hilton Plant Beds.
4. Magnesium Limestones.
3. Upper Brockram, interbedded with and overlain by Penrith Sandstone.
2. Penrith Sandstone.
1. Lower Brockram.
Carboniferous rocks.

The Lower Brockram forms a bold escarpment near Hoff Beck, and the nature of its constituents can conveniently be studied in great clean faces of quarries as well as in the natural exposures. In the course of a careful examination of the pebbles it was found that all the pebbles, except some twenty or thirty at most, consisted of Carboniferous limestone or chert, the former well rounded and frequently very fossiliferous. *Saccamina Carteri* was found in one. The stones ranged in size up to nearly 1 foot in diameter.

The few exceptions mentioned above were hematite, sandstone, and ten or twelve small pebbles of vein quartz such as might be found in the Millstone Grit, the Basement Carboniferous conglomerate, or, more remotely, as veins in the Skiddaw Slates. Recurrences of the same bed presenting the same characters as regards the nature and source of the pebbles are seen on the west bank of the Eden below Appleby, on Gallows Hill, and at Hungriggs Quarry, east of Appleby. At the last two localities the pebbles have been very extensively dolomitised subsequently to deposition, for they have in many cases been reduced to a mere shell, usually lined with crystals of dolomite.

The same aspect of the Lower Brockram is presented in the exposures at Stenkreth (Kirkby Stephen), and to the northward of Hungriggs in several quarries. It can be seen from these facts that for a distance of ten or twelve miles along the strike, and for over two miles on the dip, the character of the pebbles in the Lower Brockram undergoes no change.

The Penrith Sandstone about Appleby attains to a thickness of probably a thousand feet, but no exact estimate is possible owing to the occurrence of a large number of faults of unknown throw.

Near its upper boundary numerous intercalations of the Upper Brockram conglomerate occur, especially in the section in Hilton Beck.

The Upper Brockram in this section consists of a rather friable conglomerate in beds of 1 foot or 2 feet in thickness parted by beds of sandstone from a few inches up to 30 or 40 feet thick. The constituent pebbles are partly of Carboniferous limestone, very soft and much dolomitised, but other elements frequently preponderate: these are well-rounded pebbles of vein quartz, angular pebbles and blocks of quartzite, fragments of conglomerate containing vein quartz in a quartzite matrix, and finally, pebbles of rhyolite. At other exposures to the northward, *e.g.*, at Flakebridge, the same characters recur.

The source of the different pebbles may now be considered. The limestones are, of course, from the lower part of the Carboniferous series. They present no peculiar features; the pebbles of vein quartz are clearly derived from the numerous quartz veins in the Skiddaw Slate of the Cross Fell inlier, but their thoroughly rounded condition shows that they must have come at an intermediate stage through some præ-Permian conglomerate. This conclusion is confirmed by the occurrence of fragments of conglomerate containing such pebbles, which is recognisable as the very characteristic Basement Carboniferous conglomerate of the Cross Fell Range.

The angular blocks of quartzite can be matched precisely by the rocks which succeed the Basement conglomerate of Roman Fell. The author at one time regarded the rhyolites as indisputable evidence of the exposure of the Borrowdale rocks of the Cross Fell inlier, and denudation during Permian times; but, while this still seems to be the most probable explanation of their presence in the Upper Brockram, it is possible that they could have been derived from the Carboniferous Basement conglomerate, in which at Swindale Beck a few such pebbles occur.

Setting aside the rhyolite pebbles, there is still a body of evidence which seems to warrant deductions of very great interest. The facts to be explained are the occurrence in the Lower Brockram of a practically pure gathering of Carboniferous limestone, while the Upper Brockram contains a very high percentage of rocks from the very base of the Carboniferous series. They might be explained on the supposition of derivation from opposite sides of the Vale of Eden, the Lower Brockram being supposed to come from the Carboniferous limestone outcrop towards Orton, while the Upper Brockram was derived from the Pennine Range. This view has little to commend it. If the Carboniferous basement conglomerate were exposed to denudation during the deposition of the Upper Brockram, then the Carboniferous limestone must have formed a bold escarpment at the same time; and, that being granted, it is highly improbable that it failed to yield the materials of the Lower Brockram, which at Hungriggs is less than three miles from the outer Pennine Fault which exposed a series of Carboniferous rocks in Permian times. Upon the alternative and, as it seems, preferable hypothesis that the materials of the two Brockrams were all derived from the Pennine Chain, an inter-Permian movement of the faults which throw up the Cross Fell Range and the well-known inlier seems necessary.

Professor Lapworth has pointed out that when an anticlinal fold is exposed to denudation the derivative beds will consist of the same materials as those of the anticline, but in reverse order; the uppermost beds of the anticline will yield pebbles of the lowest of the derivative beds, while the core of the anticline will be represented only in the highest of the derivative beds.

This principle may be illustrated by the Tertiary beds of the south-east of England. The Lower Eocene conglomerates contain only flint pebbles from the chalk, while the high-level gravels which rest on the Bagshot series contain, besides flint, many pebbles derived from the Lower Greensand.

Where, however, the exposure is by a fault scarp, the whole of the beds exposed in the scarp will contribute to the first formed derivative conglomerates. The absence of detritus of the basement beds of the Carboniferous from the Lower Brockram shows that the basement beds were not exposed in early Permian times, but a movement of the fault exceeding the thickness of the Penrith Sandstone brought the lowest members of the Carboniferous series above the surface at the time of the deposition of the Upper Brockram.

9. *Report on the Erratic Blocks of the British Isles.*—See Reports, p. 252.

10. *The Conditions under which Manganese Dioxide has been Deposited in Sedimentary Rocks, as illustrated by the Elgin Sandstones. By* WILLIAM MACKIE, *M.A., M.D.*

Manganese dioxide has been observed to occur in the Elgin sandstones under the following conditions:—(1) In ovoid or rounded spots, from ⅛ inch to 6 inches in diameter, known to the quarrymen as 'vegetations,' at Newton Quarry, in U.O.R. rocks. From analyses MnO_2 varies from ·180 per cent. to ·262 per cent. (2) In small nodules, about ¼ inch in diameter, in Triassic rocks, S.E. of Cuttishillock. $MnO_2 = 12·87$ per cent. (3) In punctiform spots around decomposing felspars in sandstone of the Rosebrae division, U.O.R. sandstones = ·0715 per cent. of MnO_2. (4) In small spots or lining minute cavities, and evidently following carbonate of lime, in Triassic rocks at Spynie and Lossiemouth, MnO_2 = ·035 per cent. (5) In veins or lining joints, occasionally parallel to and some distance back from the joint-plane. An example from Bishopmill, U.O.R., gave MnO_2 1·27 per cent. + MnO ·27 per cent. (6) Along the upper surface and occasionally irregularly diffused through the interbedded clayey bands of the Rosebrae division. (7) Uniformly diffused through the sandstone in the same way as the much more frequently occurring ferric hydroxide. Seen at Newton, Millstone, and Cloves quarries in the U.O.R. (8) In some organic remains in the same formation a scute of *Bothriolepis major* gave MnO 2·33 per cent., of *Psammosteus taylori* ·83 per cent. (9) As a brown or blackish staining on the casts of organic remains. (10) As illustrative examples are cited fragments of cherty limestone in the local boulder clays, with their interstices filled with MnO_2, the carbonate of lime having been totally removed, and a specimen of 'black' sand from under boulder clay on the Banffshire coast, MnO_2 6·58 per cent. + MnO ·48 per cent.

Experiments made by allowing a dilute solution of manganese sulphate—thirty grains to the gallon—to drip slowly on various rocks and sandstones, showed that common chalk and sandstone containing carbonate of lime were darkened in colour within twelve hours. Sandstones without carbonate of lime were not darkened. If the specimens were first moistened with dilute ammonia, caustic soda or potash, or the carbonated alkalies, darkening to a degree took place very rapidly. Free ammonia was found to exist in every specimen of sandstone from the area examined, and to be particularly plentiful in Newton sandstone. An acid reaction was obtained in some of the 'black' spots at Newton, due, it was believed, to the oxidation of sulphur, which was also present. Others gave a marked alkaline reaction. The presence of ammonium chloride was also demonstrated in a number of the sandstone specimens. In the presence of ammonia and ammonium chloride, manganese is only precipitated after it is peroxidised, but peroxidisation is rapidly effected in the presence of free ammonia or other free alkali. Though the solution of ammonia and ammonium chloride in the sandstones is no doubt very dilute, it is probably, as compared with the solution of manganese in the infiltrating water, relatively strong.

Presuming the access of oxygen—which may be taken for granted in the case of porous rocks like sandstones—the explanation of the precipitation of manganese dioxide simply resolves itself into accounting for a preponderance of alkalinity at the special points of precipitation of that substance. Analyses show that the manganese areas contain excess of lime, magnesia, and alkalies, compared with what obtains in the surrounding sandstones. This may have been a cause of increased alkalinity, and hence of the precipitation of the manganese dioxide. On the other hand, it may simply be a concomitant of the precipitation, and due to the same cause. The alkalinity in some of the manifestations enumerated has undoubtedly been due to carbonate of lime (1), (2), (4), (8), (9); to the ammonia arising from the decomposition of organic remains (1), (8), (9); to the presence of carbonated alkalies (3), (5), (6), (7); and to free ammonia of the sandstone water after the total precipitation of the ferric hydroxide in a higher zone of the sandstones (7). The conditions that are necessary for the precipitation of manganese dioxide are the presence of alkali or alkaline substance in excess, soluble manganese compounds in transit, and facility for oxygenation.

There is nothing particularly unique in the precipitation of manganese dioxide. It is simply an extension or continuation of the same action as determines the precipitation of ferric hydroxide, and a general separation is effected between the two substances by the fact that the iron compounds fall out before the manganese as the infiltrating water containing them encounters further and further supplies of alkali. The general distribution of the two substances in the Elgin sandstones illustrates this natural method of separation, the rocks impregnated with secondary infiltration of ferric hydroxide in a general way occurring in a zone overlying those impregnated with manganese dioxide.

In the author's opinion the manganese nodules of the deep-sea deposits owe their origin to the operation of the same or similar causes.

As a general summary it may be stated that the principles involved in Weldon's process for the recovery of manganese were long anticipated and had long been in operation in Nature's processes before Weldon's day.

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11. *The so-called 'Fossil' Water of Sedimentary Strata, as illustrated by the Sandstones of the Moray Firth Basin. By* WILLIAM MACKIE, *M.A., M.D.*

A series of determinations of the soluble chlorides and sulphates locked up in the interstices of the Elgin sandstones was made to test the thesis that from such an examination it is possible to determine the character, as to freshness or salinity, of the waters of the basin of deposit of a series of sedimentary rocks.

In the present case, though some interesting side issues were no doubt made manifest, the results as regards the main issue were found to be entirely negative. In all, thirty-eight determinations were made: seven in L.O.R. rocks, seventeen in U.O.R., six in Triassic, one in Jurassic, and for the purposes of illustration seven in recent deposits. The averages obtained were:—

	Cl per cent.	SO_4 per cent.
L.O.R.	·0101	·0180
U.O.R.	·0077	·0064
Triassic	·0050	·0051
Jurassic	·0037	·0113
Recent	·0049	·0042

Average over all—Cl, ·0063 per cent.; SO_4, ·009 per cent.

Some interest attaches to these averages in relation to the question of the saltness of the sea. They show at least that a fairly large proportion of that saltness may reasonably be referred to the washing-out in past times of the chlorides and sulphates from sedimentary rocks.

The increase shown by these averages from the younger to the older formations—or, to put it otherwise, from the overlying to the underlying rocks—may be ascribed to the washing-in of the soluble salts from the surface and concentration in the depths; but doubt may be expressed if that covers the whole case.

Remarkable variations were obtained in specimens of the same sandstone even when collected in the same quarry. These variations were in some cases so extreme as to preclude any general conclusion as to the character of the waters of the basin of deposit. It was also found that the percolation of rain-water may reduce the chlorides to ·0005 per cent. or less, and the sulphates to a like quantity, or even to entire absence. Water passing down joints and fissures, it was also found, tends to wash back the soluble salts and concentrate them at some distance back from the fissures. Chlorides, and less frequently the sulphates, were found to increase in rocks secondarily stained with ferric hydroxide, and also in the manganese areas referred to in the author's paper. It has been shown elsewhere that traces of the heavy metals are disseminated through the Elgin sandstones generally, and also tend to increase in relative proportion in the manganese areas. Increases in lime, magnesia, and alkali have also been demonstrated as obtaining in the same areas. From the intimate relationship of all these substances it is inferred, with some degree of certainty, that they formed part of the same general infiltration. If so, it must also be inferred at the same time that the original 'fossil' water of these sandstones must have long ago been washed out, or at least seriously masked in the process. Generally it may be said that such washing-out of the original 'fossil' water may have taken place anywhere, and that the results of subsequent infiltrations may have themselves been replaced again and again by other infiltrations, and so on. The inference therefore, that the soluble salts of a series of deposits represent the salts of the original waters of the basin of deposit must in the majority of instances be a very uncertain one, if indeed any degree of certainty can be claimed for such an inference under any circumstances.

MONDAY, SEPTEMBER 15.

The following Papers were read:—

1. *On the Structure of Ireland.*

By Professor GRENVILLE A. J. COLE, *F.G.S.*

The more prominent phases of the geological history of Ireland were pointed out, mainly as an explanation of the existing scenic features of the country. Probably very little remains in Ireland of the old Huronian continent, unless portions of it have appeared again in the cores of Caledonian folds. The stratified but metamorphosed 'Dalradians' of the west may be Cambrian, or older; and gneiss is included in the granite of Eastern Tyrone, the latter being probably of Caledonian age. The gneiss of the ancient moorland between Omagh and Cookstown is, moreover, very probably præ-Cambrian. The Silurian sea must have covered all the Irish area; and the subsequent Caledonian folding, with its axes running north-east and south-west, marked out the first distinct lines of the existing country. The arches became filled with molten rock as they rose, and denudation has again and again exposed in them a core of granite. To this folding we owe the guiding lines of Donegal, Sligo, and Mayo; the axis of Newry, which reaches from the sea—and, indeed, from Scotland—down into the midland counties; and, above all, the long mass of the Leinster Chain, the most important feature of South-eastern Ireland. The granites weather into round-backed moorlands; the schistose foothills give rise to picturesque ridges and ravines upon their flanks. In the Dublin area, between the foothills and the sea, quartzites and slates, usually regarded as Cambrian, have added the prominent features of Howth, Bray Head, and the two Sugarloaves to an already diversified landscape.

The Old Red sandstone lakes spread across the hollows of the Caledonian continent, to be succeeded by the inflow of the Carboniferous sea. The Lower Carboniferous beach-deposits are now found on the summits of west Irish mountains, and very little of the country can have escaped submergence. The Hercynian folding produced the second series of structural lines, assisted by the varying resistance of the Old Red sandstone and the Carboniferous limestone to denudation. The east-and-west anticlinal ridges, from the Atlantic to the Irish Channel, with intervening valleys, where the limestone is protected in the synclinals, repeat on a bold scale the structure of South Wales and Belgium. The folds swung round in the neighbourhood of the pre-existing Leinster Chain; and the axis of the Kilkenny coalfield, where the coal measures remain on a high synclinal, runs north-east and south-west, like its Caledonian neighbour on the east. The great limestone plain itself is probably to be looked on as a vast shallow synclinal of the same epoch, into which, in later periods, the Caledonian and Hercynian ridges poured down their detritus.

Marine Permian beds occur near Stewartstown, south-west of Lough Neagh, and also in the north of Co. Down. The terrestrial conditions of the British Trias were continued into the Irish area, but the remaining beds of this period all lie north of Dublin, and mostly owe their preservation to the capping of Cainozoic basalt. The Rhætic sea penetrated as far west as the Caledonian hills of Londonderry, and marine conditions continued during early Liassic times. An uplift then probably occurred, and the sea did not return till the middle of the Cretaceous period. The 'White Limestone,' which forms so distinctive a feature of the Antrim coast, represents the English Chalk.

The great feature of the north is, however, due to volcanic eruptions of Eocene age. Owing to the immense outpouring of basalt across the uplifted Cretaceous and earlier strata, the counties of Antrim and Londonderry include high igneous plateaux, cut by deep valleys in which the underlying rocks are seen. The landscapes close around Belfast reveal the structure of the country in perfection. In the west of Ireland dykes of basalt, running characteristically north-west and south-east, are so frequent as to show that the plateaux once prevailed from Down to the Atlantic coast. Sporadic eruptions occurred even in the Galway area, and basalt fragments prevail on the sea-floor between Ireland and Rockall. The granite of the Mourne Mountains was intruded in the same period of unrest, and the pinnacles and rocky walls of the group are a sign of youth when compared with the older granite areas in Ireland.

The existing surface of northern Ireland was determined by the falling-in and dislocation of the volcanic country that once spread northward to the Faroe Isles. Lough Neagh thus lies in a shallow basin formed during this epoch of subsidence and decay. The long sea-inlets of the north and west, including Belfast Lough and the 'rias' and 'fjords' of Connemara and Kerry, originated about the same time; but Ireland, now cut off from the lost continent on the north-west, became joined on to the growing continent of Cainozoic Europe. The spread of ice in glacial times is marked by numerous hills of gravel and eskers, especially in the central plain, where they form green ridges rising from the bogland and the prairie. The oscillations of level that occurred between the glacial epoch and the present day finally left Ireland cut off from Scotland, Wales, and England, with which her fundamental geological structure so obviously connects her. It is interesting to note that the most prominent features of her landscapes at the present day depend on structures impressed upon the area far back in Palæozoic times.

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2. *On the Fossil Fishes of the Lower Devonian Roofing-slate of Gemünden in Germany.* *By* R. H. TRAQUAIR, *M.D., F.R.S.*

The fossils of the Lower Devonian beds, known as the Hunsrück Slates in western Germany, are marine in character, and mainly represented by starfishes, crinoids, trilobites, cephalopods, and bivalve shells, corals and brachiopods being rare, while at one locality, namely, Gemünden, beautifully preserved fish-remains occur. These fossils are all pyritised, and consequently microscopic examination is impossible. The fishes chiefly belong to *Drepanaspis gemündenensis* of Schlüter, a singular ostracoderm fish with a mailed body, a scaly tail, and heterocercal tail-fin, but no limbs, no teeth, and no true jaws. It is allied to the Pteraspidæ. The author next showed photographs of a new and remarkable fish to which he gave the name of *Gemündina stürtzi*, the affinities of which were doubtful, though on the whole pointing in the direction of the Selachii, or sharks and rays. It had expanded pectoral fins like a ray, a pointed tail, a vertebral column with ring-like centra, while the skin was covered with ossifications, passing on the tail into longitudinal rows of scutes. A new species of *Coccosteus* (*C. angustus*, Traq.), characterised by the narrow contour of the ventral cuirass, was next described. This is the first record of *Coccosteus* in the Lower Devonian strata of Europe. The fourth form shown belonged to the genus *Phlyctænaspis*, characteristic of the Lower Devonian rocks of Herefordshire and of Canada, and was represented by a portion of the head of a new species, *Ph. germanica*, Traq. The last of these fish-remains treated of in the present paper was an interesting vertebral column, to which, however, the author did not deem it advisable to affix a name in the meantime.

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3. *On the Prolongation of the Highland Border Rock into Co. Tyrone.* *By* G. BARROW.

The author gives a brief account of the rocks, Jasper and Green Rock Series, occurring along the southern margins of the Highlands in Kincardineshire. He then notes these occurrences along the southern Highland border.

The occurrence of the same rocks in Anglesea and in N. Wales is also noted and the evidence as to their age briefly referred to.

A brief account is then given of their widespread outcrop north of Pomeroy, and it is shown that they bear the same relation to the Highland rocks as in Kincardineshire, *i.e.*, the two series are separated by a persistent thrust plane. This had been previously traced by Mr. McHenry, though his work is not published

The metamorphism of the series by granitic intrusions is briefly referred to, and the age of the various groups discussed.

Taking into account the evidence from the different areas, the author concludes that the Highland rocks are the oldest, and are of Archæan age.

The Jasper and Green Rock Series though newer are most probably of præ-Cambrian age, and not Arenig, as the author formerly supposed. These views agree in the main with those put forward by Mr. Kinahan, to whom the credit of establishing the præ-Cambrian age of these Green Rocks is primarily due.

4. *The Fossil Flora of the Cumberland Coalfield.*

By E. A. NEWELL ARBER, *M.A.*, *F.G.S.*

The Cumberland coalfield lies along the coast-line to the west of the mountains of the Lake District. The towns of Whitehaven, Workington, and Maryport are three of the most important centres of the coal industry in Cumberland. In this district the Upper Carboniferous rocks consist of two series, of which the upper is the well-known 'Whitehaven Sandstone.' This is essentially an arenaceous deposit, and is often red or purple in colour. It is generally believed to lie unconformably on the 'Coal Measures' below, the latter consisting of argillaceous and carbonaceous material, and containing almost all the workable coals.

The horizons of both the 'Whitehaven Sandstone' and the 'Coal Measures' in the Carboniferous are disputed questions. Recently some attempt has been made to throw fresh light on the subject, from the evidence of the plant-remains which occur in both series, although not so abundantly as in some other coalfields. A full account of the floras, and the conclusions which have been attained, will, it is hoped, be published shortly elsewhere.

5. *The Post-Glacial Deposits of the Belfast District.*

By R. LLOYD PRAEGER.

The silted-up head of Belfast Lough and other similar places in the district display a remarkably fine series of deposits extending from the close of the Glacial epoch to the present day, with a rich fauna, from which much of the history of the intervening period may be gleaned. A typical section at Belfast shows the following sequence:—

	Feet	Inches
Surface clays	6	6
Yellow sand	2	0
Blue clay { Upper	6	0
Blue clay { Lower	6	0
Grey sand	2	0
Peat	1	6
Grey sand	2	0
Red sand	4	0
Boulder clay (base not reached)	15	0
	45	0

The peat bed, which at Belfast is 20 feet below low-water level, reappears between tides at various other places in the district. It represents an old land surface, and its fossils include the 'Irish Elk.' The blue clay is the most important bed of the series. Two divisions can be clearly distinguished in it, the lower clay being littoral, and characterised by such shells as *Scrobicularia piperata*, the upper yielding an abundant fauna pertaining to five to ten fathoms of water; *Thracia convexa* is a characteristic fossil. In both clays some of the bivalves occur in beds, each shell in its natural position, and many of the species attain remarkably large proportions. In places the *Scrobicularia* clay is overlaid by raised beaches. Thus, at Larne, 20 feet of stratified gravels, containing marine shells and neolithic implements throughout, replace the *Thracia* clay, and serve to date it. The fauna of the *Thracia* clay has a distinctly southern aspect when compared with the present fauna.

As regards oscillations of level, the peat proves a level higher than the present in certain places by at least 30 feet. Subsidence, irregular both as regards rate and area affected, superseded to the extent of 50 to 80 feet; the final elevation, which brought about the existing state of things, amounted to 30 or 40 feet.

As regards climate, the northern fauna of the Glacial period appears to have passed away by the time the peat was formed. Southern species immigrated till the molluscan fauna acquired a distinctly southern character in the upper blue clay; then the seas became again colder, and the present local molluscan fauna has a distinctly northern aspect.

TUESDAY, SEPTEMBER 16.

The following Reports and Papers were read:—

1. *Report on the Movements of Underground Waters of N.W. Yorkshire.* See Reports, p. 224.

2. *Report on the Collection and Preservation of Photographs of Geological Interest.*—See Reports, p. 229.

3. *On the Valleys at the Head of the Hardanger Fjord, Norway.*

By HORACE WOOLLASTON MONCKTON, *F.L.S., F.G.S.*

Above the head of the Hardanger Fjord there is a great moorland with a level of over 2,000 feet. It is an old land-surface of at least pre-Glacial date, with rounded hills and wide shallow valleys.

The plateau upon which the snowfield Hardanger Jökul lies and a few mountain tops attain a still higher level, and may, as suggested by Dr. Reusch, be remains of a far older land-surface.

In the moorland deep narrow valleys have been cut, probably the result of a rise of the land before or at an early part of the Glacial period. It is suggested that the hollow in which the Hardanger Fjord lies may have been excavated at the time of this elevation.

The author traces the course of the River Bjoreia, across the pre-Glacial surface to the Vöringfos (waterfall), where it plunges into the deep narrow valley Maabödal. He agrees with Dr. Reusch that the precise direction of this valley is due to lines of weakness, or cracks in the rock, and that the valley is not a fissure valley, but has been excavated by water assisted by ice.

The author was struck by the resemblance of the head of the valley at the Vöringfos to a giant's chaldron, and suggests that much of the excavating may have been the work of sub-Glacial streams when ice covered the surface.

The Maabövand, a talus-dammed lake, is described. Below it the river enters the side of a wide section of the valley, and possibly the head of the valley was at one time at this point.

A little below Tveit there appears once to have been a small lake formed by moraine.

At Sæbö the valley unites with Hjælmodal, and some interesting terraces are described.

Below is the lake Eidfjordsvand, formed by a great moraine. Dr. Brögger has shown that during the early part of the Ice age the land stood much higher than now. Subsequently depression took place, but towards the close of that period elevation again set in, and the terraces at Sæbö and others below the Eidfjordsvand are the result of this last elevation.

4. *The Evidence of the Hydrothermal Metamorphism of the Schists of South Devon.* *By* A. R. Hunt, *F.G.S.*

The author contends that a dominant cause of alteration in the Devonshire schists was the presence of water; in other words, that as the presence of some degree of heat is not disputed the metamorphism was hydrothermal.

He divides the schists into two groups:—

1. Rocks which have been variously called chlorite-schists, hornblende-schists, epidote-schists—or, generally, green rocks.
2. Mica-schists, more or less associated with quartz-schists.

The schists of the first group are, he observes, usually attributed to the alteration of basic augitic rock; they were originally composed of anhydrous minerals, pyroxenes, and felspars.

Evidence is adduced to show that they now have become transformed into rock, consisting of amphibole, epidote, zoisite, and chlorite; the three last of these contain water of crystallisation, together with albite, which in these rocks is occasionally charged with actual water. In short, he remarks that the one characteristic substance which by way of addition distinguishes the green rocks from their assumed parents is water.

He then deals with the second group, showing a similar result.

Thus, he maintains, the hydro-metamorphism of the district seems pretty well established, and contends that whilst thermo-dynamic metamorphism is admitted in South Devon, the universal presence of water in the newly constituted rocks compels us to assign a very important position to hydro-metamorphism as an agent of change. It is not so much that water must have been present during the metamorphic process, as that it is in the rocks now, and could not have been introduced since their crystallisation.

5. *Note on the Scenery of Ceylon.*
By A. K. Coomáraswámy, *B.Sc., F.L.S., F.G.S.*

It is probable that Ceylon has been exposed to continuous denudation since very early Palæozoic times. The foliation of the crystalline rocks has had a marked influence in determining the directions of the river valleys and the general configuration of the country. The foliation strike is usually from N. to N.W. Many rivers have a similar direction, as examination of a map will show. A north-and-south strike-valley runs from Wattegama to Dambulla, followed by the railway as far as Matale. N.N.W. valleys are conspicuous N. of Hunasgiriya. The Mahaweli Ganga valley, south of Peradeniya, is a strike-valley; another good example is the valley running N.W. from Hatton. Each of these valleys is followed by the railway. Other conspicuous N.W. valleys (probably strike-valleys) are those between Kurunegala and Matale; and N.E. of Adam's Peak and S. of Ratnapura. A small area east of Kandy has been examined in detail, and shows a diagrammatic system of strike-valleys, with others at right angles thereto, the strike being here, however, more nearly east and west than is usually the case. The bands of limestone may have had some effect in determining the actual positions of these valleys. Of course *all* valleys in Ceylon are not strike-valleys; thus the Mahaweli Ganga valley crosses the general strike below Gettembe (E. of Peradeniya), forming a series of rapids.

A characteristic feature of the scenery of Ceylon in many parts is its precipitous character; the seemingly 'bedded' granulites form mural escarpments and dip slopes, as if they were a series of sedimentary rocks.

The above remarks apply only to the mountainous districts which occupy the south central part of Ceylon. A low coastal plain fringes the island, partly of alluvial and partly of raised beach origin; sea cliffs are absent or very unusual, and even any coast exposures of rock are not common. In the north a greater area is flat and low, and the scenery resembles that of Southern India. Isolated hills of gneiss (Dambulla, Sigiri, &c.) rise conspicuously from the plain.

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6. *On some New Fossils from Penmorfa, and their Bearing on the Cambro-Ordovician Succession near Tremadoc.* *By* W. G. FEARNSIDES, *B.A., F.G.S.*

The beds between the mid-Lingula Flags of the hill west of Penmorfa Church and the fossiliferous beds of Penmorfa village show a continuous succession.

The black upper Lingula Flags include near their base a 4-inch band of limestone made up of *Orthis lenticularis*, and about 100 feet higher a band full of *Parabolina spinulosa, Sphærophthalmus alatus, Ctenopyge pecten*, and especially *Agnostus rex*. Another band some 30 feet higher is the one which yielded to Ramsay and later workers their best specimens of 'Lower Tremadoc' Trilobites, especially *Niobe homfrayi* and *Psilocephalus innotatus*: these are associated with Theca, Hymenocaris, and small Trilobites, probably new.

About 50 feet higher comes the Dictyonema zone, crowded with Dictyonema itself: it is underlain by a hard 'indicator' bed of flags with small Acrotreta. I have followed the Dictyonema zone from Penmorfa round the west and south of Moel-y-Gest as far as Borthwood, and find that at Wern and Llanerch, as at Tyn-llan, it overlies the beds from which Ramsay obtained his 'Lower Tremadoc' fossils. Then follow some 300–400 feet of as yet unfossiliferous shales and flags, which pass continuously up to the thin band of calcareous and micaceous flags exposed in front of the Post Office at Penmorfa. These beds have yielded me a rich fauna which is closely related to that of the Sheinton beds of Shropshire, but is even more like that of the shallow-water development of Ceratopyge shales described by Moberg from the island of Oeland:—

Shumardia cf. *oelandica*
Symphysurus croftii
Euloma monile
Olenus triarthrus
Olenus salteri
Macrocystella mariæ

(All Sheinton species.)

Ceratopyge forficula
Cheirurus cf. *foveolatus*
Bellerophon cf. *norvegica.*

Species abundant in Sweden, but hitherto unknown in Britain.

With these are several new forms, and excellent specimens of all the well-known Tremadoc species:

Dicellocephalus furca, Conocoryphe verisimilis, Ogygia Selwynii (forms usually referred to as 'Lower Tremadoc'); *Angelina sedgwickii*, var.; *Cheirurus fredrici, Ampyx ? prænuntius*, and very many *Asaphellus homfrayi* (forms usually termed 'Upper Tremadoc').

These beds are overlain by similar but less fossiliferous shales which yield, along with Asaphellus, the normal form of *Angelina sedgwickii*. Above this the beds are disturbed and often converted into an Augen-shale, which in places contains masses of the well-known pisolitic iron ore of Tremadoc.

At a spot on the 500-foot contour 300 yards N., 5° W., of the farm Tyddyn-dicwm-uchaf, I have obtained graptolites *in situ*. These Miss Elles has kindly determined for me as follows:—

Didymograptus superstes
Cænograptus gracilis
Dicellograptus sextans
Dicellograptus intortus
Dicellograptus caduceus
Dicranograptus ramosus
Dicranograptus zigzag, var. *minimus*
Glossograptus hincksii
Diplograptus whitfieldi
Climacograptus scharenbergi
Diplograptus angustifolius ?

These fossils occur in a band of hard blue slate, which only splits after being exposed to the weather for a time. It passes up into a crushed Augen-shale, containing ashy material, and appears to be the bed immediately underlying the earliest volcanic ash-beds of this region.

7. *Preliminary Note on a Carboniferous Fish Fauna from Victoria, Australia. By* A. Smith Woodward, *LL.D., F.R.S.*

The researches of Dr. Traquair have proved that in Britain there is a definite succession of Devonian and Carboniferous fish faunas. When sufficiently well-preserved fossils are available, these faunas can be readily distinguished and recognised, and they always occur in the same stratigraphical order. There is also considerable evidence of a similar succession on the continent of Europe, in Spitzbergen, and in North America.

Much interest was therefore aroused, twelve years ago, when the late Sir Frederick M'Coy announced that a mixture of representatives of all these different faunas had been discovered in a bed of Palæozoic Red Sandstone in Australia.[1] These fossils were found at the supposed base of the Carboniferous system in the valley of the Broken River, near Mansfield, Victoria. The first fragments were discovered by Mr. Reginald Murray; a large series of remains was afterwards collected by the Rev. A. Cresswell for the Geological Survey of Victoria; and valuable additions were also made by Mr. George Sweet, F.G.S., of Melbourne. The complete collection was placed in the Melbourne Museum, and Sir Frederick M'Coy's report was the result of his preliminary study of it.

Unfortunately, notwithstanding the interest of this important discovery, no definite information concerning it has hitherto been published. Before his death M'Coy was only able to supervise the drawing of some plates to illustrate a memoir which he hoped to prepare. The specimens proved to be too fragmentary, and the materials for comparison in the Australian museums too inadequate for him to arrive at any satisfactory results. The whole collection has therefore been sent to me by Professors Baldwin Spencer and J. W. Gregory; and at present I am engaged in the work of preparing the projected memoir for the Geological Survey of Victoria.

With ample facilities for the study of the collection, it now appears that M'Coy's original report was based on a complete misinterpretation of many of the fragments. Far from displaying a 'mixture of Lower Devonian, Upper Devonian, and types related to some of the Calciferous Sandstone series,' as M'Coy supposed, the Broken River collection is typically and essentially Carboniferous; and some of the specimens are of great interest, both from the ichthyologist's and from the geologist's point of view.

None of the specimens or drawings are labelled with the names proposed for them by M'Coy, and none of his manuscript notes are forthcoming. I am thus unable to recognise all his identifications with certainty. Most of them, however, are distinguishable; and it is, in any case, sure that I have the whole of the material which was at his disposal.

The fossils regarded by M'Coy as Lower Devonian in facies received the names of *Rytidaspis murrayi* and *Pteraspis* (?) *mansfieldensis*. The former was said to be of the same shape as *Cephalaspis*, the latter not more than generically distinct from *Pteraspis*. There are, however, in the collection no remains either of Cephalaspidians or Pteraspidians, or any types related to them. I do not know to which fossil the name *Rytidaspis* was applied, but it is evident that impressions of some gular plates of a large Rhizodont fish were mistaken for the supposed *Pteraspis*.

The determination of the remains claimed to be of a later Devonian type is equally unsatisfactory. The only Acanthodian sufficiently well preserved for discussion is not specially related to the Devonian forms, but has the elongate shape characteristic of the genera of the Carboniferous and Permian periods. The Acanthodian fragment compared with the Devonian *Cheirolepis* (which is not an Acanthodian) is too imperfect for consideration. The so-called scales of the Devonian *Glyptolepis*, or an allied genus, evidently belong to the large Rhizodont already mentioned, and closely resemble the scales of the Lower Carboniferous *Rhizodus* itself. The Australian fish, however, does not belong to the latter genus: it has teeth round in transverse section.

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[1] F. M'Coy, 'Report on Palæontology for the year 1889,' *Ann. Rep. Sec. Mines*, Victoria, 1889 (1890), pp. 23, 24.

The most interesting of all the genera represented in the collection is one rightly recognised by M'Coy as an Elasmobranch allied to the Carboniferous *Gyracanthus*. It is named *Gyracanthides*, and is a round-bodied Acanthodian fish, apparently toothless, with the comparatively small and spinous pelvic fins advanced far forwards, as in *Acanthodes*. Its dorsal fins have not been observed, but its small anal fin is armed with a spine.

There is also evidence of a small Dipnoan fish with teeth and scales like those of the Carboniferous and Permian *Sagenodus*. The typically Carboniferous Palæoniscidæ in the collection are related to *Elonichthys*.

There is thus no abnormal mingling of genera in the Early Palæozoic fish fauna from the Broken River, Victoria. It is a typical Carboniferous assemblage without any extraneous elements.

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8. *A Summary of the Principal Changes in South-east England during Pliocene and more Recent Times. By* HORACE WOOLLASTON MONCKTON, *F.L.S., F.G.S.*

(*a*) *Period of depression in South-east England.*

1. Deposition of the bed from which the Box Stones came.

2. The Lenham Beds. Sea 40 fathoms, extends to Guildford, shells not rolled level 1,000 feet lower than now (Diestian).

(*b*) *Elevation in South-east England, but depression continues over estuary of Rhine.*

3. Gravel with large flints of Upper Hale, Aldershot, and the Pebble Gravel 'Westleton' of the Chilterns.

4. Coralline Crag, submarine banks in rather shallow water; climate that of South Europe.

5. Red Crag of Walton and Scaldisian of Belgium; seashore deposits, climate rather warmer than now.

The beds with *Corbula gibba* (Poederlian) complete Belgian series, and that country becomes dry land.

6. Red Crag of Bentley, Newbourn, Butley, seashore deposits. The Amstelian of Holland. Climate colder.

(*c*) *The depression of the estuary of the Rhine extends to South-east England.*

7. Norwich Crag deposited in sea-water of wide estuary. Chillesford Clay, shells not rolled or water-worn, level lower than now.

8. Weybourne Crag and Bure Valley Beds, depression extending and consequent introduction of *Tellina balthica*.

(*d*) *Period of great and extensive elevation.*

9. Cromer Forest Bed, level and climate as now.

10. Leda Myalis Bed, marine with oyster-beds, shells in position of life. Slight local depression.

11. The Chobham Ridges Gravel and the Plateau Gravels around Reading over 300 feet O.D. come in here.

12. Arctic Freshwater Bed, flood loam with *Succinea*.

The shells of Bridlington Shell Bed lived about this time.

13. The Cromer Till and Contorted Drift. First great ice-sheet. Lower Boulder Clay of many places, Bridlington Shell Bed, and Shell Bed of Moel Tryfaen, &c. Land higher than now.

(*e*) *Depression possibly only local in South-east England.*

14. The Middle Glacial Sand and Gravel, result from melting ice.

(*f*) *Period of renewed great elevation possibly continuous with period* (*d*) *in the far north.*

15. The Great Chalky Boulder Clay. Ice-sheet extending over large area.

N.B.—At some time during Periods (*d*), (*e*), (*f*), the land in North Europe was raised to some 8,000 feet higher than now, and this is probable date of completion of excavation of Scottish lochs and Norwegian fjords.

(*g*) *Period of depression.*

16. Corbicula fluminalis Beds of Grays and Crayford. Mammilliferous beds of Sewerby and Hessle. Slight depression.

Marine Gravel of Holderness 100 feet O.D., Brighton, Goodwood, &c., Raised Beaches. Further depression.

(*h*) *Period of elevation over large area. Last great ice-sheet.*

17. Plateau Gravel of Norfolk in part, and much of the Thames Terrace-gravel, Purple and Hessle Clay of Yorks.

Shell-banks of Rockall, &c., show elevation of Iceland, Scotland, Norway, to some 600 feet higher than now.

18. Mundesley 'River Bed' near close of this period.

Probably the Raised Beach of Clacton, &c., belongs to a final period of depression (time of Yoldia Clay of Christiania), and in Norway there was a subsequent elevation during which the terraces in the fjords were formed.

9. *Report on Life-zones in the British Carboniferous Rocks.*

See Reports, p. 210.

SECTION D.—ZOOLOGY.

PRESIDENT OF THE SECTION—Professor G. B. HOWES, D.Sc., LL.D., F.R.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

The Morphological Method and Progress

IT is now twenty-eight years since this Association last assembled in Belfast, and to those present who can recall the meeting the proceedings of Section D will be best remembered for the delivery of an address by Huxley 'On the Hypothesis that Animals are Automata, and its History,' one of the finest philosophic products of his mind.[1] At that date the zoological world were about to embark on a period of marked activity. Fired by the influence of the 'Origin of Species,' which had survived abuse and was taking immediate effect, the zoological mind, accepting the doctrine of evolution, had become eager to determine the lines of descent of animal forms. Marine observatories were in their infancy; the 'Challenger' was still at sea; the study of comparative embryology was but then becoming a science; and when, reflecting on this, we briefly survey the present field, we can but stand astonished at the enormity of the task which has been achieved.

Development has proceeded on every hand. The leavening influence, spreading with sure effect, has in due course extended to the Antipodes and the East, in each of which portions of the globe there have now arisen a band of earnest workers pledged to the investigation of their indigenous fauna, with which they are proceeding with might and main. Of the Japanese, let it be said that not only have they filled in gaps in our growing knowledge, for which they alone have the materials at hand, but that, with an acumen deserving the highest praise, they have put us right on first principles. I refer to the fact that they have shown, with respect to the embryonic membranes of the common chick, that we in the West, with our historic associations, our methods, and our skill, contenting ourselves with an ever-recurring restriction to the germinal area, have, by an error of orientation, missed an all-important septum, displaced under an inequality of growth.[2]

Those of us who have lived and worked throughout this memorable period have had a unique experience, for never has there been progress so rapid, accumulation of observations so extensive and exact. Of the 386,000 living animal species, to compute the estimate low,[3] every one available has been lain under hand, with the result that our annual literary output now amounts to close upon 10,000 contributions, the description of new genera and sub-genera, say 1,700. More than one half of this vast series refer to the Insecta alone; but notwithstanding this, the records of facts of structure and development, with which most of us are concerned, now amount to a formidable mass, calculated to awe the unlettered looker-on, to overwhelm the earnest devotee, unless by specialising he can secure relief. As an example of what may occur, it may be remarked that a recent exploration of the great African lakes has resulted in the discovery of over 130 new species.[4]

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[1] For List of References see p. 636.

As to the nature of this unprecedented progress, it will suffice to consider the Earthworms. In 1874 few were known to us. An advance in our knowledge, which had then commenced, had made known but few more which seemed likely to yield result. Darwin's book upon them had not appeared. Some were exotic, it is true, but no one suspected that a group so restricted in their habits could reveal aught beyond a dull monotony of form and structure. Never was surmise more wide of the mark, for the combined investigations of a score of earnest workers in all parts of the world have in the interval recorded some 700 odd species of about 140 genera.[5] Mainly exotic, they exhibit among themselves a structural variation of the widest possible range. Not only do we recognise littoral and branchiate forms, but others achætous and leech-like in habit, to the extent of the discovery of a morphological overlap with the leeches, under which we are now compelled to remove them from their old association with the flat worms, and to unite them with the earthworms. And we even find these animals, as represented by the *Acanthodrilidæ*, coming prominently into considerations which involve the theory of a former antarctic continent, one of the most revolutionary zoo-geographical topics of our time.[6]

This case of the earthworm may be taken as typical of the rest, since for each and every class and order of animal forms, the progress of the period through which we have passed since last we assembled here has produced revolutionary results. Our knowledge of facts has become materially enhanced; our classifications, at best but the working expression of our ideas, have been to a large extent replaced in clearer, more comprehensive schemes; and we are to-day enabled to deduce, with an accuracy proportionate to our increased knowledge of fact, the nature of the interrelationships of the living forms which with ourselves inhabit the earth.

Satisfactory as is this result, it must be clearly borne in mind that its realisation could not have come about but for a knowledge of the animals of the past; and turning now to palæontology, it may be said that at the time of our last meeting in this city the scientific world were just becoming entranced, by the promise of unexpected results in the exploration of the American Tertiary beds, then being first opened up. The Rocky Mountain district was the area under investigation, and with this, as with the progress in our knowledge of recent forms, no one living was prepared for the discoveries which shortly came to pass. To consider a concrete case, we may premise that study of the placental mammals had justified the conclusion that their ancestors must have had equal and pentadactyle limbs, a complete ulna and fibula, a complete clavicle, and a skull with forty-four teeth; must have realised, that is, the predominant term of the living Insectivora as generally understood. Who among the zoologists of our time does not recall with enthusiasm the revelation which arose from the discovery, during these early days, in the Eocene of Central North America, of the genera at first described as *Eo-* and *Helohyus*?[7] The evidence of the existence, in the locality named, of these forty-four toothed peccaries, as they were held to be, rendered clearer the records of the later Tertiary deposits of the old world, which were those of hogs, and, in correlation with the facts then known, suggested that the Rocky Mountain area was the home of the ancestral porcine stock, and that in Early Tertiary times their descendants must have migrated, on the one hand, across the northern belt, of which the Aleutian Islands now mark the course, into the old world, to beget, with complication of their teeth, the pigs and hogs; and on the other into Central South America, to give rise, with numerical reduction of teeth and toes, to the peccaries, still extant.

Migration in opposite directions with diversity of modification was the refrain of this remarkable find, far-reaching in its morphological and zoo-geographical effects. Nor can we allude with less fervour to the still more striking case of the horses, indicating not merely a similar, though perhaps a later, migration, but a parallelism of modification in both the old and new worlds, culminating in the latter in extinction, whereby it became necessary, on the advent of civilised man, to carry back the old-world horse to its ancestral American home. No wonder that this should have provoked our Huxley to the remark that in it we have the 'demonstrative evidence of the occurrence of evolution,' and that the facts of palæontology came to be regarded as certainly not second to those of the fascinating but seductive department of embryology, at the time making giant strides.[8]

I have endeavoured thus to picture that state of zoological science at the time of our last meeting here; and I wish now to confine myself to some of the broader results since achieved on the morphological side. But let us first digress, in order to be clear as to the meaning of this phrase.

We do not expect the public to be accurate in their usage of scientific terms; but it is to me an astounding fact that among trained scientific experts, devotees to branches of science other than our own, there exists a gross misunderstanding as to the limitations of our departments. I quote from an official report in alluding to 'comparative anatomists, or biologists, as they call themselves,' and I but cite the words of an eminent scientific friend, in referring to biology and botany as coequal. In endeavouring to get rid of this prevailing error, let it be once more said that the term 'biology' was introduced at the beginning of the nineteenth century by Treviranus and Lamarck, and that in its usage it has come to signify two totally distinct things as employed by our Continental contemporaries and ourselves. By 'Biologie' they understand the study of the organism in relation to its environment. We, following Huxley, include in our term biology the study of all phenomena manifested by living matter; botany and zoology; and by morphology we zoologists mean the study of structure in all its forms, of anatomy, histology, and development, with palæontology—of all, that is, which can be preferably studied in the dead state, as distinct from physiology, the study of the living in action. Comparative morphology, the study of likeness and unlikeness, is the basis of our working classifications, and it is to the consideration of the morphological method, and the more salient of its recent results that I would now proceed, in so far as it may be said to have marked progress and given precision to our ideas within the last eight-and-twenty years. I would deal in the main with facts, with theories only where self-evident, ignoring that type of generalisation to which the exclusive study of embryology has lent itself, which characterises, but does not grace, a vast portion of our recent zoological literature.

To the earnest student of zoology, intent on current advance, the mental image of the interrelationships of the greater groups of animal forms is ever changing, kaleidoscopically it may be, but with diminishing effect in proportion as our knowledge becomes the more precise.

Returning now to American palæontology, we may at once continue our theme. In this vast field, expedition after expedition has returned with material rich and plentiful; and while, by study of it, our knowledge of every living mammalian order, to say the least, has been extended, and in some cases revolutionised, we have come to regard the Early Tertiary period as the heyday of the mammals, in the sense that the present epoch is that of the smaller birds. No wonder then that there should have been discovered group after group which has become extinct, or evidence that in matters such as tooth-structure there is reason to believe that types identical with those of to-day have been previously evolved but to disappear.[9] To contemplate the discovery of the Titanotheria,[10] the Amblyopoda,[11] the Dinocerata with their strange diminutive brain,[12] chief among the heavier ungulate forms, is to consider the Mammalia anew; and when it is found that among late discoveries we have (1) that of a series of Rhinoceratoidea, which though not yet known to extend so far back in time as the primitive tapirs and horses are complete as far as they go;[13] (2) that among the Ruminants we have, in the Oreodontidæ of the American Eocene, primitive forms with a dentition of forty-four teeth, an absence of diastemata, a pentadactyle manus, a tetradactyle pes with traces of a hallux, and, as would appear from an example of *Mesoreodon*, a bony clavicle, such as is unknown in any later ungulate, we are aroused to a pitch of eager enthusiasm as to the outcome of labours now in hand;[14] for, as I write, there reaches me a letter, to the effect that for most of the great vertebrate groups, and not the mammals alone, collections are still coming in, each more wonderful than the last.[15]

In the extension of our knowledge of the Ancylopoda,[16] an order of mammals named after the *Ancylotherium* of Pikermi and Samos, which occur in the Early Tertiary deposits of Europe, Asia, North America, and abundantly in Patagonia,[17] we have been made aware of the existence of genera whose salient structural features combine the dentition of an ungulate with the possession of pointed claws, believed to have been retractile like those of the living cats. Conversely to these unguiculate herbivores, which include genera with limbs on both the artio- and perisso-dactyle lines, there have been found, among the so-called Mesonychidæ, undoubted primitive carnivores, indications of a type of terminal phalanx seal-like and approximately non-unguiculate;[18] from all of which it is clear that we have in the rocks the remains of forms extinct which transpose the correlations of tooth and claw deducible from the living orders alone. Further, among the primitive pentadactyle Carnivora we meet, in the genus *Patriofelis*, with a reduction of the lower incisors to two, and characters of the fore limb which, with this, suggest the seals.[19] It is, however, probable that these characters are in no way indicative of direct genetic relationship between the two, for, inasmuch as these animals were accustomed to seek their food in the water of the lake by which they dwelt, their seal-like characters may be but the expression of adaptation to a partially aquatic mode of life—of parallelism of modification with the seals and nothing more.

Early in the history of their inquiry, our American confrères recorded from the Pliocene the discovery of camel-like forms possessed of a full upper incisor dentition; for example, the genera *Protolabis* and *Ithygrammodon*;[20] and now they have arrived at the conclusion that while the camels are of American origin one of their most characteristic ruminants, the Prongbuck (*Antilocapra*), would conversely appear to be the descendant of an ancestor (*Blastomeryx*) who migrated from the old world.

Sufficient this concerning the work in mammalogy of the American palæontologists. While we return them our devout and learned admiration, we would point out that the brilliance of their discoveries has but beclouded the recognition of equally important investigations going on elsewhere. In Argentina there have proceeded, side by side with the North American explorations, researches into the Pleistocene or Pampa fauna, which in result are not one whit behind,[21] as has been proved by the recognition of a whole order of primitive ungulates, the Toxodontia,[22] by that of toothed cetaceans with elongated nasals, as in the genera *Prosqualodon* and *Argyrocetus*, and of sperm whales with functional premaxillary teeth, viz., *Physodon* and *Hypocetus*, to say nothing of giant armadillos and pigmy glyptodons.[23]

It will be remembered by some present that, from Patagonian deposits of supposed Cretaceous age, there was exhibited at our Dover meeting the skull of a horned chelonian *Miolania*, which animal, we were informed, is barely distinguishable from the species originally discovered in Lord Howe's Island, and Queensland, and which, being a marsh turtle highly specialised, would seem in all probability to furnish a forcible defence for the theory of the antarctic continent.[24] But more than this, the results of renewed investigation of the Argentine beds by the members of the Princeton University of North America have recently resulted in collections which, we are informed, seem likely to surpass all precedent in their bearings upon our current ideas, not the least remarkable preliminary announcement being the statement that there occurs fossil a mole indistinguishable, so far as is known, from the golden mole (*Chrysochloris*) of South Africa.[25]

Before I dismiss this fascinating subject let me disarm the notion, which may have arisen, that the palæontological work of the old world is done. Far from it! Even our American cousins have to come to us for important fossil forms; as, for example, the genus *Pliohyrax* of Samos and the Egyptian desert,[26] while among the rodents and smaller carnivores there are large collections in our national museum waiting to be worked over afresh.

If one part of the globe more than another is just now the centre of interest concerning its vertebrate remains, it is the Egyptian desert. Here there have recently been found the bones of a huge cetacean associated, as in South America, with those of a giant snake, one of the longest known, since it must have reached a length of thirty feet.[27] There also occur the remains of other snakes, of chelonians of remarkable adaptive type, of crocodilians, fishes, and other animals. Interest, however, is greatest concerning the Mammalia, which for novelty are quite up to the American standard, as with an upper and a lower jaw of an anomalous creature, concerning which we can only at present remark that it may be a marsupial, or more probably a carnivore, which has taken on the rodent type in a manner peculiarly its own.[28] Important beyond this, however, are a series of Eocene forms which more than fill a long-standing gap, viz., that of the ancestors of the Elephants and Mastodons, which hitherto stopped short in the Middle Miocene of both old and new worlds. As represented by the genus *Mœritherium*, they have three incisors above and two below, of which the second is in each case converted into a short but massive tusk. An upper canine is present, and in both upper and lower jaws a series of six cheek-teeth, distinct and bunodont in type.[29] In the allied *Barytherium*, of which a large part of the skeleton is known, the upper incisors were presumably reduced to two, the tusks enlarged, with resemblances in detail to the Dinoceratan type.[30]

So far as these remains are known, they appear to present in their combined characters all that the most ardent evolutionist could desire. There are with them Mastodons which simplify our knowledge of this group; and among the last discovered remains Sirenians, which, in presenting a certain similarity to the afore-named Mœritherium, strengthen the belief in the proboscidian relationships of these aquatic forms.[31] Finally, and perhaps most noticeable of all, there is the genus *Arsinoitherium*, a heavy brute with an olfactory vacuity which outrivals that of *Grypotherium* itself, and is surmounted by a monstrous fronto-nasal horn, swollen and bifid, for which the most formidable among the Titanotheres might yearn in vain. There is an occiput to match! The suggestion that this extraordinary beast has relationships with the Rhinoceridæ is absurd, since its tooth pattern alone inverts the order of this type. That it is proboscidian may be nearer the mark, and if so it shows once more how subtle were the mammals of the past.[32] Great as is this result, much remains to be done or done again, if only from the fact that in seeking to determine homologies our American brethren, in the opinion of some of us, have placed too much reliance on a so-called tritubercular theory of tooth genesis, of which we cannot admit the proof.[33] How, we would ask, is it conceivable that a transversely ridged molar of the *Diprotodon* type can be of tritubercular origin?

Sufficient for the moment of palæontological advance, except to remark that the zoologist who neglects this branch of morphology misses the one leavening influence; neglects the court on whose ruling arguments deduced from embryological data alone must either stand or fall. We may form our own conclusions from facts of the order before us; but it is when we find their influence on the master-mind prompting to action, like that of Huxley with his mighty memoir of 1880, in which he revised our sub-class terms, that we appreciate them to the full.[34]

With this consideration we pass to the living forms, and I have only time in dealing with these to comment on advance which affects our broadest conceptions and classifications of the past.

To commence with the Mammalia, we now know that the mammary gland when first it appears is in all forms tubular, and that this type is no longer distinctive of the Monotremata alone.[35] We know, too, that the intranarial position of the epiglottis when at rest, long known for certain forms, is a distinction of the class. It explains the presence of the velum palatinum, by its association with the glottis for the restriction of the respiratory passage, the connection being lost in man alone, under specialisation of the organ of the voice.[36]

Similarly, the doubly ossified condition of the coracoid may now be held diagnostic, for it is known that the epicoracoidal element, originally thought to characterise the monotremes alone, is always present, and that reduction to a varying degree characterises the metacoracoid, which retires, as in man, as the so-called coracoid epiphysis.[37]

Our conceptions of the interrelationships of the Marsupialia and Placentalia have during the period we are considering been delimited beyond expectation, by the discovery that an allantoic placenta in a polyprotodont marsupial, replaces the vitelline, present in its allies.[38] When it is remembered that in the formation of the placenta of the rabbit, bat, and hedgehog, there is a provisional vitelline stage,[39] it is tempting to suggest that the evidence for the direct relationship of the two mammalian sub-classes first named overlaps (there being a placental marsupial on one hand, a marsupial placental on the other), much as we have come to regard Archæopteryx as an avian reptile, the Odontornithes as reptilian birds. These facts, moreover, prove that the type of placenta inherited by the Placentalia must have been discoidal, and that from that all others were derived.

Equally important concerning our knowledge of the Marsupialia is the discovery, first made clear by Professor Symington, of this College, that Owen was correct in denying them a corpus callosum.[40] How Owen arrived at this conclusion it is difficult to conceive; but in these later days the history of discovery is largely that of method; and it is by the employment of chrome-silver, methylene-blue, and other reagents, which in differentiating the fibre-tracts enable us to delimit their course, that this conclusion has been proved. By the corpus callosum we now understand a series of neo-pallial fibres which transect the alveus and are present only in the Placentalia.[41]

There is no department of mammalogy in which recent work has been more luminous than this which concerns the brain; and, to mention but one result, it may be said that in the renewed study of the commissures there has been found a fibre-tract characteristic of the Diprotodontia alone, so situated as to prove that they and the Placentalia must have specialised on diverse lines from a polyprotodont stock.[42] Interesting this, the more, since the phalangers and kangaroos are known to be polyprotodont when young.[43] And when we add the discovery that in the form of its hippocampal commissure the brain of the Elephant Shrew, a lowly insectivore, alone among that of all Placentalia known realises the marsupial state,[44] as does its accessory organ of smell, we have to admit the existence of annectant conditions just where they should occur.[45]

The morphological method is sound!

The master hand which has given us this result has also reinvestigated the Lemurs. From an exhaustive study of the brain or its cast of all species of the order, living and extinct, there has come the proof that the distinctive characters of the lemuroid brain are intelligible only on a knowledge of the pithecoid type; that its structural simplicity in the so-called lower lemurs is due to retrogressive change, in some species proved to be ontogenetic; and that the Tarsier, recently claimed to be an insectivore, is a lemur of lemurs.[46] It is impossible to over-estimate the importance of this conclusion, which receives confirmation in recent palæontological work;[47] and there is demanded a reinvestigation of those early described Tertiary fossil forms placed on the Ungulo-lemuroid border line, as also a reconsideration of current views on the evolution of the primates and of man.[48]

In dismissing the Mammalia, we recall the capture during the period we review of three new genera, a fourth, the so-called *Neomylodon*,[49] having proved by its skull to be *Grypotherium darwinii*, already known.[50] The African Okapi, an object of sensation beyond its deserts, has found its place at last. To have been dubbed a donkey, a zebra, and a primitive hornless giraffe, is distinction indeed; and we cannot refrain from contrasting the nonsensical statement that its discovery is 'the most important since Archæopteryx' with the truth that it is a giraffine, horned in the male, annectant between two groups well known.[51] As a discovery it does not compare with that of the Mole-marsupial,[52] and it falls into insignificance beside that of the South American diprotodont *Cænolestes*, the survivor of a family which there flourished in Middle Tertiary times.[53]

Passing to Birds and Reptiles, it will be convenient to consider them together. A knowledge of their anatomy has extended on all hands, and in respect to nothing more instructively than their organs of respiration. Surprise must be expressed at the discovery, in the chelonian, of a mode of advancing complication of the lung suggestive of that of birds. On looking into this, I find that Huxley, who rationalised our knowledge of the avian lung and its sacs,[54] was aware of the fact that in our common Water-tortoise (*Emys orbicularis*), the lung is sharply differentiated along the bronchial line into a postero-dorsal more cellular mass, an antero-ventral more saccular, of which the posterior vesicle, in its extension and bronchial relationships, strangely simulates the so-called abdominal sac of birds. He had already instituted comparison with the Crocodiles,[55] and was clearly coming to the conclusion that the arrangement in the bird is but the result of extreme specialisation of a type common to all Sauropsida with a 'cellular' lung. The respiratory process in the bird may be defined as *transpulmonary*, and it is an interesting coincidence that, as I write, there comes to hand a memoir, supporting Huxley's conclusion, and establishing the fact that there is a fundamental principle underlying the development and primary differentiation of all types of vertebrate lung.[56]

The discovery of the Odontornithes in the American Cretaceous is so well known, that it is but necessary to remark that nine genera and some twenty species are recognised.[57] To *Archæopteryx* I shall return. Before dismissing the Chelonia, however, it must be pointed out that palæontology has definitely clenched their supposed relationship to the Plesiosaurs. Of all recent palæontological collections there are none which, for care in collecting and skill in mounting, surpass the reptilian remains from the English Jurassic (Oxford Clay) now public in our national museum.[58] The Plesiosaurs of this series must be seen to be appreciated, and nothing short of a merciful Providence can have interposed to ensure the generic name *Cryptocleidus*, which one of them has received, since the hiding of the clavicle, its diagnostic character, is an accomplished fact. It is due to secondary displacement, under the approximation in the middle line of a pair of proscapular lobes, present in the Plesiosauria and Chelonia alone, and until the advent of this discovery misinterpreted.[59] Taken in conjunction with other characters of little less importance, conspicuously those of the plastron and pelvis, this decides the question of affinity, and proves the Chelonia to have had a lowly ancestry, as has generally been maintained.[60]

Recent research has fully recorded the facts of development of the rare New Zealand reptile *Sphenodon*, and it has more than justified the conclusion that it is the sole survivor of an originally extensive and primitive group, the Rhynchocephalia, as now understood.[61] To confine our attention to its skeleton, as that portion of its body which can alone be compared with both the living and extinct, it may be said that positive proof has been for the first time obtained that the developing vertebral body of the terrestrial vertebrata passes through a paired cartilaginous stage, and that in its details the later development of this body is most nearly identical with that of the lower Batrachia.[62] There has long been a consensus of opinion that the forward extension of the pterygoids to meet the vomers in the middle line, known hitherto in this animal and the crocodiles alone, is for the terrestrial Vertebrata a primitive character; and proof of this has been obtained by its presence in all the Rhynchocephalia known. The same condition has also been found to exist in the Plesiosaurs,[63] the Ichthyosaurs,[64] the Pterodactyles,[65] the Dicynodontia,[66] the Dinosaurs,[67] and with modification in some Chelonians.[68] It has, moreover, been found in living birds; [69] a most welcome fact, since *Archæopteryx*, in the possession of a plastron, carries the avian type a stage lower than the Dinosaurs. It is pertinent here to remark that, inasmuch as in those Dinosaurs (e.g., *Compsognathus*) in which the characters of the hind limbs are most nearly avian, the pelvis, in respect to its pubis, is at the antipodes of that of all known birds, and the fore limb is shortened in excess of that of *Archæopteryx* itself, the long supposed dinosaurian ancestry for birds must be held in abeyance.[70]

Passing through the Rhynchocephalia to the Batrachia, we have to countenance progress most definite in its results. The skull, the limbs and their girdles, are chiefly concerned, and this in a very remarkable way.

In the year 1881 there was made known by Professor Froriep, of Tübingen, the discovery that the hypoglossus nerve of the embryo mammal is possessed of dorsal ganglionated roots.[71] Again and again have I heard Huxley insist on the fact that the ventral roots of this nerve are serial with the spinal set, but never did he suspect the rest. It is, however, a most intensely interesting fact that, whereas by a Huxleian triumph the vertebral theory of the skull was overthrown, in these later Huxleian days the proof of the incorporation of a portion of the vertebral region of the trunk into the mammalian occiput should have marked the succeeding epoch in advance. The existence of twelve pairs of cranial nerves which all the Amniota possess involves them in this change; and the fact that in all Batrachia there are but ten, enables us to draw a hard and fast line between batrachian and amniote series.

It may be urged, as an objection, that since we have long been familiar with a fusion of vertebræ and skull in various piscine forms, the force of this distinction is weakened. But this cannot be; since, in respect to the investing sheaths and processes of development which lie at the root of the genesis of the vertebral skeleton, the fishes stand distinct from the Batrachia and Amniota, which are agreed.[72] So forcible is this consideration that it behoves us to express it in words, and I have elsewhere proposed to discriminate between the series of terrestrial Vertebrata as *archæ-* and *syn-craniate.*[73]

Similarly there is no proof that any batrachian, living or extinct (and in this I include the Stegocephala as a whole), possesses a costal sternum. So far as their development is known, the cartilages in these animals called 'sternal' are either coracoidal or *sui generis.*[74] The costal sternum, like the syncraniate skull, is distinctive of the Amniota alone. Had the Stegocephala possessed it even in cartilage, there is reason to think it might have been preserved, as it has been in the colossal Mososaur *Tylosaurus* of the American Cretaceous.[75] When to this it is added that whereas, in the presence of a costal sternum, the mechanism of inflation of the lung involves the body-wall, in its absence it mainly involves the mouth (as in all fishes and batrachians), the hard and sharp line between the Batrachia and Amniota may be expressed by the formula that the former are *archæcraniate* and *stomatophysous*, the latter *syncraniate* and *somatophysous.*

There are allied topics which might be considered did our time permit; but one certain outcome of this is that there is an end to the notion of a batrachian ancestry for the Mammalia. And when, on this basis, we sum up the characters demanded of the stock from which the Mammalia have been derived, we find them to be precisely those occurring outside the Mammalia in the Anomodont Reptiles alone. Beyond the sternum and skull, the chief characters are the possession of short and equal pentadactyle limbs, with never more than three phalanges to a digit, a complete fibula and clavicle, a doubly ossified coracoid, a heterodont dentition—a combination which, wholly or in part, we now associate with the Permian genera *Procolophon, Pariasaurus,* and others which might be named, the discovery of which constitutes one of the morphological triumphs of our time.[76]

Beyond this, it may be added, concerning the Batrachia, that among living pedate forms the Anura have alone retained the pentadactyle state and the complete maxillo-jugal arch, and that the Eastern *Tylototriton*, in the possession of the latter, becomes the least modified urodele extant.[77] These facts lead to the extraordinary conclusion that the living Urodela, while of general lowly organisation, are one and all aberrant; and it is not the least important sequel to this that, despite their total loss of limbs, the Apoda, in the retention of the dermal armour and other features which might be stated are the most primitive Batrachia that exist.[78]

The batrachian phalangeal formula 22343 was until quite recently a difficulty in the determination of the precise zoological position of the class; but it has now been overcome, by the discovery of a *Keraterpeton* in the Irish Carboniferous having three phalanges on the second digit of both fore and hind limbs,[79] and by that in the Permian of Saxony of a most remarkable creature, *Sclerocephalus*, which, if rightly referred to the Stegocephala, had a head encased, as its name implies, in an armature like that of a fish, and the phalangeal formula of a reptile, 23454.[80]

Passing from the Batrachia to the Fishes, we have still to admit a gap, since an interminable discussion on fingers and fins has not narrowed it in the least. In compensation for this, however, we have to record within the fish series itself progress greater, perhaps, than with the higher groups. Certainly is this the case if, as to bulk, the literature in systematics and palæontology be alone taken into account.

Of the Dipnoi our knowledge is fast becoming complete. We know that *Lepidosiren* forms a burrow ;[81] and, in consideration of a former monstrous proposal to regard this animal, with its fifty-six pairs of ribs, and *Protopterus*, with its thirty to thirty-five, as varieties of a species,[82] it is the more interesting to find that the Congo has lately yielded a *Protopterus* (*P. dolloi*) with the lepidosiren rib formula, viz., fifty-four pairs.[83]

As a foremost result of American palæontological research we have to record the occurrence, in the Devonian of Ohio, of a series of colossal fishes known as the Arthrodira, the supposed dipnoan affinities of which are still a matter of doubt.[84]

We have evidence that the osseous skeleton in a plate-like form first appeared as a protection for the eye of a primitive shark.[85] And coming to recent forms having special bearings on the teachings of the rocks, we have to acknowledge the capture in the Japanese seas of a couple of ancient sharks, of which one (*Chlamydoselachus*), since observed to have a distribution extending to the far North, is a survivor from Devonian times; the other (*Mitsukurina*), a genus whose grotesqueness leaves no doubt of its identity with the Cretaceous lamnoid *Scapanorhynchus*.[86] In the elucidation of the Sturiones and the determination of their affinities with the ancient Palæoniscidæ a master stroke has been achieved.[87] In the Old Red genus *Palæospondylus* we have become familiar with an unmistakable marsipobranch, possessing, as do certain living fishes, a notochord, annulated, but not vertebrated in the strict sense of the term.[88] The climax in Ichthyopalæontology, however, has been reached, in the discovery of Silurian forms, which, there is every reason to believe, explain in an unexpected way the hitherto anomalous Pteras- and Cephalaspidians, by involving them in a community of ancestry with the primitive Elasmobranchs. The genera *Thelodus*, *Drepanaspis*, *Ateleaspis*, and *Lanarkia*, chief among these annectant and ancestral forms, are among the most remarkable vertebrate fossils known.[89]

Passing to the Recent Fishes alone, the discovery which must take precedence is that of the mode of origin of the skeletogenous tissue of their vertebral column. The fishes, unlike all the higher Vertebrata, have, when young, a notochord invested in a double sheath, there being an inner chordal sheath, an outer cuticular, which latter is alone present in all the higher groups. The skeletogenous cells, by whose activity the cartilaginous vertebral skeleton is formed, arise outside these sheaths; but whereas, when proliferating, they in one series remain outside, they in the other, by the rupture of the cuticular sheath, invade the chordal. This distinction enables us to discriminate between a *Chordal series*, which embraces the Chimæroids, Elasmobranchs, and Dipnoi, and a *Perichordal*, consisting of the Teleosts, Ganoids, and Cyclostomes.[90]

In consideration of the enormity of the structural gap between the cyclostomes and the higher Vertebrata this is an extraordinary result. For be it remembered that, in addition to their well-known characters, the lampreys and hags (1) in the total absence of paired fins; (2) in the presence of branchiæ, ordinarily seven in number, fourteen in *Bdellostoma polytrema*,[91] numerically variable in individuals of certain species between six and fourteen, and doubtfully asserted in the young of one to be originally thirty-five ;[92] and (3) in the carrying up of their oral hypophysis by the nasal organ, whereby it perforates the cranium from above, as contrasted with all the higher Vertebrata, in which, carried in with the mouth-sac, it perforates it from beneath, exhibit morphological characters of an extraordinary kind. And if we are to express these characters in terms, we may distinguish the Cyclostomes as *apterygial* and *epicraniate*, the higher Vertebrata as *hypocraniate*.[93] [1] But this notwithstanding, the aforementioned subdivision of the

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[1] It is an interesting circumstance, if their 'ciliated sac' is rightly homologised, that *Amphioxus* and the Tunicata present a corresponding dissimilarity, allowance being made for the fact that in *Botryllus*, *Goodsiria*, and *Polycarpa* the sac overlies the ganglion.[94] It is pertinent here to recall the ammocœte-like condition of the 'endostyle' in *Oikopleura flabellum*.[95]

Pisces into two series, which would associate the teleosts and ganoids with the cyclostomes, as distinct from the rest, receives support from recent study of the head-kidney by a Japanese, who seeks to show that the organ so called in the Elasmobranchs is of a late-formed type peculiar to itself; [96] and it is also in agreement with one set of conclusions previously deduced from the study of the reproductive organs.[97]

To deal further with the fishes is impossible in this Address, except to remark that recent discovery in the Gambia that the young of the Teleostean genera *Heterotis* and *Gymnarchus* bear filamentous external gills, renders significant beyond expectation the alleged presence of these among the loaches, and shows that adaptive organs of this type are valueless as criteria of affinity.[98]

In palæontology, as in recent anatomy, our records of detail have increased beyond precedent, often but to show how deficient in knowledge we are, how contradictory are our theories and facts.

In dismissing the fishes, I wish to comment upon our accepted terms of orientation. To speak of the median fins as dorsal, caudal, and anal, of the pelvic as ventral, and of the pectoral in its varying degrees of forward translocation as abdominal or thoracic, though a convention of the past, is to-day inaccurate and absurd. I question if the time has not come at which the terms thoracic (pulmo-cardiac) and abdominal are intolerable, as expressing either the subdivisions of the body-cavity or anything else, outside the Mammalia, which alone possess a diaphragm. Even in the birds, to grant the utmost, the subdivision of the cœlom if accurately described, must be into pulmonary, hyper-pulmonary, and cardio-abdominal chambers; while with the reptiles the modes of subdivision are so complex that a special terminology is necessary for each of the several types extant.

In the fishes, where the pericardium is alone shut off, the retention of the mammaliam terms but hampers progress. This was indeed felt by Duméril, when in 1865 he attempted a revisionary scheme.[99] Since, however, one less fantastic than his seems desirable, I would propose that for the future the 'anal' fin be termed *ventral*, the 'ventral' *pelvic*; and that for the several positions of the pelvic, that immediately in front of the vent, primitive and embryonic (which is the position for the Elasmobranchs, Sturiones, Lower Siluroids, and all the higher Vertebrata), be termed *proctal*, the so-called 'abdominal' *pro-proctal*, the so-called 'thoracic' *jugular* (in that it denotes association with the area of the 'collar-bone'), and the so-called 'jugular' *mental*. The necessity for this becomes the more desirable, now that it is known that a group of Cretaceous fishes (the Ctenothrissidæ), hitherto regarded as Berycoids, are in reality of clupeoid affinity, despite the fact that at this early geological period they had translocated their pelvic fin into the jugular ('thoracic') position.[100]

The sum of our knowledge acquired during the last twenty-eight years proves to us that, among the bony fishes, the structural combination which would give us a premaxillo-maxillary gape dentigerous throughout, a proctal pelvic fin, a heart with conal valves, would be the lowest and most primitive. Inasmuch as this character of the heart, so far as at present known, exists only among the Clupesoces (pikes and herrings and their immediate allies), these must be regarded as lowly forms; [101] wherefore it follows that the possession of but a single dorsal fin is not, as might appear, a necessary index of a highly modified state.

Before I dismiss the vertebrates, a word or two upon a recent result of morphological inquiry which concerns them as a whole. I refer to the development of the skull. Up to 1878 it was everywhere thought and taught that the cartilaginous skull was a compound of paired elements, known as the trabeculæ cranii and parachordals, and that the former contributed the cranial wall. Huxley in 1874, from the study of the cranial nerves of fishes, had reiterated the suggestion he made in 1864, when dealing with the skull alone, that the trabeculæ might be a pair of præ-oral visceral arches, serial with those which support the mouth and carry the gills. The next step lay with the Sturgeon, in which in 1878 it was found that the cranial wall is originally distinct.[102] And later, when the facts were more fully studied in sharks, batrachians, reptiles, and birds, it became evident that the trabeculæ, though ultimately associated with the cranial wall, take no share in its formation, and that when first they appear they are disposed at right angles to the parachordals and the axis, serially with the visceral arches behind.[103] Huxley was right; and although this consideration by no means exhausts the category of independent cartilages now known to contribute to the formation of the skull, it proves that the cartilaginous cranium, like the bony one, which in the higher vertebrate forms replaces it, is in its essence compound.

I now pass to the Invertebrata. Of the Oligochæta and Leeches I have spoken, and we may next consider the Arthropods. Of the Insecta, our knowledge has gained precision, by the conclusion that the primitive number of their Malpighian tubes is six, and by the study of development of these in the American cockroach *Doryphora*, which has rendered it probable they may be modified nephridia, carried in as are those of some oligochætes with the proctodeal invagination.[104] An apparent cervical placenta has been discovered in the orthopteran *Hemimerus*, which suggests homology with the so-called 'trophic vesicle' of the Peripatoids, as exemplified by *Parap. novæ-britannica*.[105] In this same orthopteran there have been recognised, in secondary proximity to the 'lingua,' reduced maxillulæ, which, fully developed and interposed between the mandible and first maxilla, in *Japyx*, *Machilis*, *Forficula*, and the *Ephemera* larva, give us a fifth constituent for the insectan head.[106] And when it is found that all the abdominal segments of a common cockroach, when young, are said to bear appendages, of which the cerci are the hindermost,[107] we have a series of facts which revolutionise our ideas. Little less striking is the discovery that in the caterpillar of the bombycine genera *Lagoa* and *Chrysopyga* seven pairs of pro-legs occur.[108]

The fuller study of the apertures of the tracheate body has resulted in the discovery that the Chilopoda are more nearly related to the Hexapoda than to the Diplopoda; wherefore it is proposed to reclassify the Tracheata, in accordance with the position of the genital orifice, into *Pro-* and *Opistho-goneata*.[109] In a word the 'Myriapoda,' if a natural group, are diphyletic.

Our knowledge of the Peripatoids (Arthropoda malacopoda) has increased in all that concerns distribution and structure. They are now known, for example, from Africa, the West Indies, Australia, and New Zealand, and for examples from the two latter localities and Tasmania the generic name *Ooperipatus* has but lately been proposed, to include three species characterised by the possession of an ovipositor, of which two have been observed to lay eggs.[110]

Work upon the Crustacea in our own land, notorious for the tendencies of some of its devotees in their stickling for priority, has within the last twelve years advanced beyond all expectation. Much of our literature has been systematised, and an enormous increase in our knowledge of new forms has to be admitted, thanks to memoirs such as those of the 'Investigator,' 'Naples Zoological Station,' and others which might be named; while in the discovery and successful monographing, in the intervals of six years' labour at other groups, of a new family of minute Copepods (the Choniostomatidæ), parasitic on the Malacostraca, embracing forty-three species, difficult to find, we have an almost unique achievement.[111] The hand which gave us this has also provided a report which embraces the description of a nauplius of exceptional type, which, by a process of reasoning by elimination, masterly in its method, has been 'run to ground' as in every degree of probability the larva of Darwin's apodal barnacle *Protolepas bivincta*, of which only the original specimen is known.[112]

There is but one other crustacean record equal in rank with this, viz., the discovery of the genus *Anaspides*. Originally obtained from a fresh-water pool on Mount Wellington, Tasmania, at 4,000 feet, it has since been found in two other localities.[113] It is unique among all living forms, in combining within itself characters of at least three distinct sub-orders of 'prawns,' for with a schizopod body it combines the double epipodial lamellæ of an amphipod, the head of a decapod (pedunculated eyes and antennulary statocysts) apart from characters peculiarly its own. There is reason to believe that the nearest living ally to this remarkable creature is a small eyeless species (*Bathynella natana*) obtained from a Bohemian well; [114] and if its presumed relationships to the Palæozoic 'pod-shrimps' be correct, this heterogeneous assemblage may perhaps be the representatives of a group of primitive Malacostraca, through which, by structural divergence, the establishment of the higher crustacean sub-orders may have come about.

It is pertinent to this to note that work upon cave-dwelling and terrestrial forms, upon 'well-shrimps' and the like, has produced important results. And interesting indeed is the recent discovery of three species, living at 800–900 feet above sea-level, in Gippsland, one an amphipod, two of them isopods, which, though surface-dwellers, are all blind.[115] While they prove to be species of genera normally eyed, they in their characters agree with well-known American forms; and the bleaching of their bodies and atrophy of their eyes proclaim them the descendants of cave-dwelling or subterranean ancestors, among whom the atrophy took place.

Huxley in 1880 rationalised our treatment of the higher Crustacea, by devising a classification by gills, expressive of the relationships of these to the limb-bases, interarticular membranes, and body-wall.[116] Hardly had his influence taken effect when, by work extending over the years 1886 to 1893, in the study of Penæus, the Phyllopods, Ostracods, and other forms, evidence had been accumulating to show that the crustacean appendage, even to the mandible itself, has primarily a basal constituent (protopodite) of three segments; that the branchiæ one and all are originally appendicular in origin; and that the numerical reduction of the basal (protopoditic) segments to two, with the assumption of a non-appendicular relationship by the gills, is due to coalescence of parts, with or without suppression.[117] The evidence for this epoch-making conclusion, which simplifies our conceptions and brings contradictory data into line, is as irresistible as it is important, and there has been nothing finer in the whole history of crustacean morphology. With it, the attempt to explain the supposed anomalous characters of the antennule by appeal to embryology goes to the wall; and, taking a deep breath, we view the Crustacea in a new light.

There remains for brief consideration one carcinological discovery second to none which bear on the significance of larval forms. It is that of the Trilobite *Triarthrus becki*, obtained in abundance from the Lower Silurian near New York, with all its limbs preserved.[118] In the simplicity of its segmentation and the biramous condition of its limbs it is primitive to a degree. Chief among its characters are the total absence of jaws in the strict sense of the term, and the fact that of its three anterior pairs of appendages the third is certainly and the second is apparently biramous, the first uniramous and antenniform. In this we have a combination of characters known only in the nauplius larva among all living crustacean forms; and the conclusion that the adult trilobite, like the Euphausiacea, Sergestidæ, Penæidæ, the Ostracods, and Cirripedes of to-day, was derived by direct expansion of the nauplius larva can hardly be doubted. Much yet remains to be done with the study of the Triarthrus limbs; and the suggestion of a foliaceous condition by those of the pygidium, which are the youngest, is a remarkable fact, the meaning of which the future must decide.[119] We should expect the condition to be a provisional one, since while we admit the primitive nature of the phyllopods as an Order, we cannot regard the foliation of their appendages as anything but a specialisation. Be this as it may, the structural community between the nauplius larva and the trilobite is now proved; and when we add that in the yolk-bearing higher Crustacean types (e.g., *Astacus*) a perceptible halt in the development may be observed at the three-limb-bearing stage; that in *Mysis* the vitelline membrane is shed but to make way for a nauplius cuticle;[120] and that the median nauplius eye has long been found sessile on the adult brain of representative members of the higher crustacean groups, up to the lobster itself,[121] our belief in the ancestral significance of the nauplius larval form is established beyond doubt.

The thought of the nauplius suggests other larval forms. The gastrula is no longer accepted without reserve; the claims of the blastula, planula, parenchymella, not to say the plakula, have all to be borne in mind.[122] It is of the Trochophore, however, as familiar as the nauplius, that I would rather speak, as influenced by recent research. It is supposed to be primitive for the molluscs and chætopod worms at least; and various attempts have been made to bolster it up, and to show that if we allow for adaptive change, its characters, well known, are constant within the limits of its simpler forms.[123]

It is now more than forty years ago that the late Lacaze-Duthiers described for *Dentalium* a larval stage, characterised by the possession of recurrently ciliated zones, which by reduction, with union and translocation forwards, give rise to the trochal lobe.[124] It is now known that in the American pelecypod *Yoldia limatula* a similar stage is found, in which a 'test,' of five rows of ciliated cells, is present; [125] and of the young of *Dondersia banyulensis* the like is true. But whereas in the *Yoldia* the ciliated sac is ultimately shed, in the Myzomenian the escape of the embryo is accompanied by rupture, which liberates the anterior series of ciliated zones in a manner strongly suggestive of forward concentration, leaving the posterior circlet with its cilia attached.[126]

This 'test' has also been seen in two species of *Nucula*, and pending fuller inquiry into the Myzomenian and a reinvestigation of Dentalium, I would suggest that this recurrently ciliated sac is representative of a larval stage antecedent to the trochophore, for which the term *protrochal* may suffice. This term has indeed been already applied to a larva of certain Polychæta, which might well represent a modification of that for which I am arguing; [127] and quite recently it appears to have been observed near Ceylon for a species of the genus *Marphysa*.[128]

The discovery of this larva in *Dondersia* was accompanied by that of a later-formed series of dorsal spicular plates, which for once and for all, in realising a chitonid stage, demolish the heresy of the 'Solenogastres,' mischievous as suggesting an affinity with the worms. Like that of the supposed cephalopod affinities of the so-called 'Pteropods,' it must be ignored as an error of the past.

Returning to the protrochal stage, whatever the future may reveal concerning it, by bringing together the Lamellibranchiata, Scaphopoda, and Polyplacophora, it associates in one natural series all the bilaterally symmetrical Mollusca except the cephalopods. In doing this, it deals the death-blow to the supposed Rhipidoglossan affinity of the Lamellibranchiata; [129] and in support of this conclusion I would point out that the recently discovered eyes of the mytilids are in the position of those of the embryo *Chiton*,[130] and that just as *Dentalium*, in the formation of its mantle, passes through a lamellibranchiate stage, so are there lamellibranchs in number in which a tubular investment is found.[131]

This protrochal larva has an important part to play. It may very possibly explain phenomena such as the compound nature of the trochal lobe of the limpet,[132] the presence of a post-oral ciliated band in the larva of the ship-worm,[133] and of a præ-anal one in that of various molluscan forms.[134] In view of it, we must hesitate before we fully accept the belief in the ancestral significance of the trochophore. And it is certain that an idea, at one time entertained, that the Rotifer (*Trochosphæra*) which so closely resembles it as to bear its name, is its persistent representative,[135] is wrong, since this is now known to be but the female of a species having a very ordinary male.

Through the Rhipidoglossa we pass to the Gastropods, which are one and all asymmetrical, for even *Fissurella*, *Patella*, and *Doris*, when young, develop a spiral shell; while Huxley in 1877 had observed that the shell of *Aplysia*, in its asymmetry, betrays its spiral source.

The notion, which until recently prevailed, that among these gastropods the non-twisted or so-called euthyneurous condition of the visceral nerve-cords, as exemplified by the Opisthobranchs, is a direct derivative of that of the Chitons has been proved to be erroneous, since the nerves in *Actæon* and *Chilina*, like those of the prosobranchs, are twisted or streptoneurous.[136] And as to the torsion of the gastropod body, recent research, in which my lamented demonstrator the late Mr. F. Woodward played a leading part, involving the discovery of paired renopericardial apertures in *Haliotis*, *Patella*, and *Trochus*, has resulted in proof that the dextral torsion which leads to the monotocardiac condition, does not affect all organs lying primitively to the left of the rectum, as we have been taught. Concerning the renal organs, it is the *primitively* (pretorsional) left one which remains as the functional kidney, its ostium as the genital aperture. Nor is the primitively right kidney necessarily lost, for while its ostium remains as the renal orifice, its body, by modification and reduction, may become an appendage of the functional kidney, the so-called nephridial gland.[137] And we now know there are cases of sinistral torsion of the visceral hump, in which the order of suppression of the organs is not reversed, the arrangement being one of adaptation of a dextral organisation to a sinistral shell.[138]

Though thus specialised and asymmetrical as a group, the gastropods are yet plastic to an unexpected degree. Madagascar has yielded a Physa (*P. lamellata*) with a neomorphic gill, a character shared by species of *Planorbis* (*P. corneus* and *P. marginatus*), and an *Ancylus* in which the lung-sac is suppressed;[139] while St. Thomas's Island has given us a snail (*Thyrophorella thomensis*), the peristome of whose shell is produced into a protective lid.[140]

In palæontology, history records the fact that in 1864 Huxley observed that the genus *Belemnites* appears to have borne but six free arms; a startling discovery which lay dormant till the present year.[141] And the recent study of the fauna of the great African lakes, in bringing to light the existence of a halolimnic molluscan series in Lake Tanganyika, has opened up new possibilities concerning the palæontological resources of enormous aqueous deposits, recently discovered in the interior, and has entirely changed our geological conceptions of the nature of Equatorial Africa.[142]

Time prevents my dealing with other groups, and it must suffice to state that with those I have not considered substantial work has been done. From what has been said, it is natural to expect that in some direction or another so vast an accumulation of facts must have extended the Darwinian teaching; and it is now quite clear that this has been the case with the two post-Darwinian principles known as 'Substitution' and Isomorphism or 'Convergence.'

The former may be exemplified by nothing better than the case of the Rays and Skates, in which, under the usurpation of the propelling function of the tail by the expanded pectoral fins, the tail, free to modify, becomes in one species a lengthy whiplash, in another a vestigial stump, in others, by the development of powerful spines, a formidable organ of defence.[143] In both the Rays and certain other fishes subject to the working of this law, modification goes further still, in the appearance of electric organs in remotely related genera and species, by specialisation of the muscular system of the trunk or tail, or, as in the case of *Malapterurus*, of 'tegumental glands.'[144] In this we have a difficulty admitted by Darwin himself, which now becomes clear and intelligible, since there is nothing new. There has simply come about the conversion, in one case of the energy of muscular contraction, in the other of glandular secretion, into that of electrical discharge, with accompanying structural change. The blind locust (*Pachyramina fuscifer*) of the New Zealand Limestone caves presents an allied case, since here, under the reduction of the eye, the antennæ, elongated to a remarkable degree, have become the more efficiently tactile; and it is an interesting question whether this principle may not explain the attenuation of the limbs in the recently discovered American Proteoid (*Typhlomolga rathburni*) of the Texan subterranean waters.[145]

And as to isomorphism, by which we mean the assumption of a similar structural state by members of diverse or independent groups, I would recall the case of the Eocene Creodont *Patriofelis* and the Seals, and that of the Myriapods to which I have already alluded, and would cite that of the Dinosaurs and Birds, heterodox though it may appear, for reasons I have given.

As our knowledge increases, there is every reason to believe that, in the non-appreciation of these principles in the past, not a few of our classifications are wrong. We have even had our bogies, as, for example, the so-called Physemaria, which deceived the very elect;[146] and before I close I wish to deal briefly with a question of serious doubt, which these considerations suggest.

It is that of the position in the zoological series of the Limuloids, popularly termed the King Crabs. These creatures, best known from the opposite shores of the Northern Pacific, but found in the oriental seas as well as far south as Torres Strait,[147] have been since 1829 the subject of a difference of opinion as to their zoological position and affinities. Within the last twenty years there have been three determined advances upon them, and of these the third and most recent may be first discussed. It has for its object the attempt to prove that they are intimately associated with the cephalaspidian and other shield-bearing fishes of the Devonian and Silurian epochs, and that through them they are ancestral to the Vertebrata. The latest phase of this idea is based on the supposed existence in a *Cephalaspis* of a series of twenty-five to thirty lateral appendages of arthropod type.[148] When, however, it is found that the would-be limbs are but the edges of body-scutes misinterpreted, suspicion is aroused; and when, working back from this, an earlier attempt reveals the fact that the author, compelled to find trabeculæ, in order to force a presupposed comparison between the architecture of the Cephalaspidian head-shield and the Limulus' prosomal hood, resorts to a comparison between the structure of the former in general and that of the cornu of the latter, with details which on the piscine side are not to date, the argument must be condemned.[149] It violates the first principles of comparative morphology, and is revolting to common sense; and as to the fishes concerned, we know that they have nothing whatever to do with the Limuloids, for we have already seen that, with their allies the Pteraspidiæ, they are a lateral branch of the ancestral piscine stem.[150]

The second advance upon the king crabs has very much in common with the first. It has engrossed the attention of an eminent physiologist for the last six or seven years, and by him it was in detail set before Section I at our meeting of 1896. Suffice it to say that it specially aims at establishing a structural community between the king crabs and certain vertebrates, favourable to the conviction that the Vertebrata have had an arthropod ancestry.[151] When we critically survey the appalling accumulation of words begotten of this task, it is sufficient to consider its opening and closing phases. At the outset, under the conclusion that the vertebrate nervous axis is the metamorphosed alimentary canal of the arthropod ancestor, the necessity for finding a digestive gland is mainly met by homologising the so-called liver of the arthropod with the cellular arachnoid of the larval lamprey, in violation of the first principles of comparative histology![152] At the close we find ingenious attempts to homologise nerve tracts and commissures related to the organs of sense, such as are invariably present wherever such organs occur.[153] Sufficient this to show that the comparison, in respect to its leading features, is in the opening case strained to an unnatural degree, in the closing case no comparison at all. Finding, as we do, that the rest of the work is on a par with this, we are compelled to reject the main conclusion as unnatural and unsound; and when we seek the explanation of this remarkable course of action, we are forced to believe that it lies in the failure to understand the nature of the morphological method. For the proper pursuit of comparative morphology, it is not sufficient that any two organisms chosen here and there should be compared, with total disregard of even elementary principles. Comparison should be first close and with nearly related forms, passing later into larger groups, with the progressive elimination of those characters which are found to be least constant. And necessary is it, above all things, that in instituting comparison it should be first ascertained what it is that constitutes a crustacean a crustacean, a marsipobranch a cyclostome, and so on for the rest. We have tried to accept this theory, fascinated both by the arguments employed and by the idea itself, which for ingenuity it would be difficult to beat, but we cannot; and we dismiss it as misleading, as a fallacy, begotten of a misconception of the nature of the morphological method of research.[154] It is of the order of events which led Owen to compare a cephalopod and a vertebrate,[155] led Lacaze-Duthiers to regard the Tunicates and Lamellibranchs as allied;[156] and with these and other heresies it must be denounced.

Passing to the third advance, extending over the last twenty years, it may be said to consist in the revival of a theory of 1829, which boldly asserts that Limulus is an Arachnid. In the development of the defence there have been two weak points but lately strengthened, viz., the insufficient consideration of the palæontological side of the question and of the presence of tracheæ among the Arachnida.[157] Under the former there was, until recently, assumed the absence of the first pair of appendages in the Eurypterida; but it may be said that they have since been observed in *Eurypterus fischeri* of the Russian Silurian,[158] and *E. scoticus* from the Pentland Hills,[159] in both of which they consist of small chelate appendages flexed and limuloid in detail, somewhat reduced perhaps, and enclosed by the bases of the succeeding limbs, which become apposed as the anterior end is reached. Since by this discovery the Limuloids, Eurypterids, and Scorpionids are brought into a numerical harmony of limb-bearing parts, we may at once proceed to other points at issue. So far as the broader structural plan of Limulus and the Scorpion are concerned, all will agree to a general community, except for the organs of respiration; but concerning the cœlom, the mobile spermatozoa, and the more detailed features under which Limulus is held to differ from the Crustacea and to resemble the Arachnida, I would remark that motile spermatozoa occur in the Cirripedes and Ostracods,[160] and that the rest of the argument is weakened, by the probability that the 'arachnidan' characters which remain may well have been possessed by the crustacean ancestors, and that Limulus, though specialised, being still an ancient form, might but have retained them. The difficulty does not seem to me to lie in this, nor with the excretory organs, if we are justified in accepting the aforementioned argument that the so-called Malpighian tubes may be inturned nephridia, ectodermal in origin, and in knowledge of the existence of endodermal excretory diverticula in the Amphipods.[161] These facts would seem to suggest that as our experience widens, differences of this kind will disappear.

As to the tracheal system, now adequately recognised by the upholders of the arachnid theory, the presumed origin of tracheæ from lung-books, the probability that the ram's-horn organ of the Chernetidæ may be tracheal,[162] the presence of tracheæ in a simple form in the Acari,[163] and, by way of an anomaly, in a highly organised form on the tibiæ of the walking legs of the harvestmen (Phalangidæ),[164] are all features to be borne in mind. While I am prepared to admit that this wide structural range and varied distribution of the tracheæ lessens their importance as a criterion of affinity, I cannot accept as conclusive the evidence for the assumed homology between lung-books and gills.[165] And here it may be remarked that a series of paired abdominal vesicles, recently found in the remarkable arachnid *Kœnenia*, invaginate as a rule but in one example everted, seized upon in defence of this homology, have not been so regarded by one most competent to judge.[166]

There remains the entosternite, an organ upon which much emphasis has been placed. Not only does a similar organ exist, apart from an endophragmal system, in the Phyllopod *Apus*, in *Cyclops*, and some Decapods; [167] but, regarding the question of its histology, it may be pointed out that from all that is at present known, the structural differences between these several entosternites do not exceed those between the cartilages of the Sepia body.[168] And when it is found that the figures and descriptions of the entosternite of *Mygale* ('Mygale sp.,' 'Mygalomorphous Spider,' *auct.*) have been twice presented upside down ! [169] the reliability of this portion of the argument is lessened, to say the least.

Recent observation has sought to clench the homology of the four posterior pairs of limbs of the King crab and Scorpion, by appeal to a furrow on the fourth segment in the former, believed to denote an original division into two; but I hesitate to accept this until myological proof has been sought.[170]

Returning, amidst so much that is problematic, to the sure ground of palæontology, I wish to point out that when all is considered in favour of the arachnid theory there still remains another way of interpreting the facts.

In both Limulus and the Scorpion the first six of the eighteen segments are well known to be fused into a prosoma bearing the limbs, but while in the Scorpion the remaining twelve are free, in Limulus they are united into a compact opisthosomal mass. In dealing with the living arthropods, there is no character determinative of position in the scale of this or that series more trustworthy than the antero-posterior fusion of segments. It has been called the process of 'cephalisation,' and the degree of its backward extension furnishes the most reliable standard of highness or lowness in a given assemblage of forms. In passing from the lower to the higher Crustacea, we find this fusion increasing as we ascend: and it therefore becomes necessary to compare the Scorpion with the other Arachnida, Limulus with the Eurypterida, in order the better to determine the position of each in its respective series, by the application of this rule.

As to the number of segments present, variation is a matter of small concern, in consideration of the mode of origin of segmentation and the wide numerical range—from seven in the Ostracods to more than sixty in Apus—the segments of the crustacean class present.

On the arachnidan side, in the Solifugæ but the third and fourth segments are fused; the remaining four of the prosomal series with the ten which remain are free.[171] In *Kœnenia* four of the prosomal segments alone unite; the fifth and sixth with the rest are free.[172] And when we pass to the Limuloids and the descending series of their allies, we find it distinctive of the Eurypterida that all the opisthosomal segments are free. If we can trust these comparisons, we must conclude that the Eurypterida of the past, in respect to their segmentation, simplify the Limuloid type, on lines similar to that on which the Solifugæ and Kœnenia simplify the Higher Arachnid and Scorpionid type, and that therefore if the degree of antero-posterior fusion of segments has the significance attached to it, *Limulus* and *Scorpio* must each stand at the summit of its respective series. If this be admitted, it has next to be asked if, in comparing them, we may not be comparing culminating types, which might well be isomorphic.

The scorpions are known fossil by two genera, *Palæophonus* and *Proscorpius*, from the Silurian of Gotland and Lanarkshire, the Pentland Hills, and New York State;[173] while recent research, in the discovery of the genus *Strabops*, has traced the Eurypterida back to the Cambrian, leaving the scorpions far behind.[174] One striking feature of the limbs of the Palæozoic Eurypterids is their constantly recurring shortness and uniformly segmented character, long known in *Slimonia*, *Eurypterus*, and *Pterygotus*, retained with development of spines in some genera, and for three of the five known appendages of the recently described eurypterid giant *Stylonurus lacoanus*.[175] The minimum length observed for these appendages is that of the Silurian species *Eurypterus fischeri*, discovered by Holm in Russia in 1898.[176] This creature is one of the few eurypterids in which all the appendages are preserved, and it is the more strange therefore that the advocates of the arachnid theory should ignore it in their most recent account. Allowing for the specialisation of its sixth prosomal appendage for swimming, the fifth is but little elongated, the second, third, and fourth are each in total length less, by far, than the transverse diameter of the prosoma, and uniformly segmented, giving the appearance of short antennæ. They seem to be seven-jointed, and are just such appendages as exist in the simpler crustacean and tracheate forms; and in the fact that their structural simplicity is correlated with the independence of the whole series of opisthosomal segments they lend support to the argument for isomorphism.

With this conclusion, we turn once more to the Scorpions, if perchance something akin to it may not be in them forthcoming. The Silurian genus *Palæophonus*, especially as represented by the Gotland specimen, reveals the one character desired. Its body does not appear to be in any marked degree simpler than that of the living forms; but on turning to its limbs, we find the four posterior pairs, in length much shorter than those of any living species, all but uniformly segmented.[177] In this they approximate towards the condition of the limbs of the Eurypterida just dismissed, and their condition is such that had they been found fossil in the isolated state they would have been described as the limbs of a Myriapod, and not of a scorpion at all. Indeed, their very details are what is required, since in the possession of a single terminal claw they differ from the limbs of the recent scorpions as do those of the Chilopoda from the hexapods.

With this the scorpionid type is carried back, with a structural simplification indicative of a parallelism with the other arthropod groups; and while the facts do not prove the total independence of the scorpionid and limuloid series, they bring the latter into closer harmony with the Eurypterida of the past. They prove that the Silurian Scorpions simplify the existing Scorpionid type, on precisely the lines on which the Eurypterida simplify the Limuloid; and they do so in a manner which suggests that a distinction between the *Crustacea vera* and the

Crustacea gigantostraca (to include the Eurypterida and Xiphosura) is the nearest expression of the truth. It becomes thereby the more regrettable that in a recent revision of the taxonomy of the Limuloids the generic name *Carcinoscorpius* should have found a place.[178]

I foresee the objection that the antenniform condition of the shorter limbs may be secondary and due to change. There is no proof of this. Against it, it may be said that the number of the segments is normal, and that where nature effects such a change, elongation is with the multi-articulate state the only process known; as, for example, with the second leg of the Phrynidæ, the so-called second pareiopod of the Polycarpidea, and the last abdominal appendage of *Apseudes*.[179]

That advances such as we have now considered should lead to new departures is a necessity of the case; and it but remains for me to remind you that within the last decade statistical and experimental methods have very properly come more prominently into vogue, in the desire to solve the problems of variation and heredity. Of the statistical method, by no means new, I have but time to recall to you the Presidential Address of 1898 by my friend and predecessor in this chair, himself a pioneer; and of the experimental method I can but cite an example, and that a most satisfactory one, justifying our confidence and support. It concerns the late Professor Milne-Edwards, who in 1864 described, from the Paris Museum, the head of a rock lobster (*Palinurus penicillatus*), having on the left side an antenniform eye-stalk.[180] With the perspicuity distinctive of his race, he argued in favour of the 'fundamental similarity of parts susceptible to revert to their opposite states.' The matter remained at this, till, on the removal of the ophthalmite of certain Crustacea, it was found that in regeneration it assumes a uniramous multiarticulate form; and it is an interesting circumstance that in the common crayfish the biramous condition normal to the antennule may occur. An example this of a fact which no other method could explain.[181]

When all is said and done, however, it is to the morphological method that I would appeal as most reliable and sound. And when we find (i.) that in certain Compound Tunicates the atrial wall, in the egg development delimited by a pair of ectoblastic invaginations, in the bud development may be formed from the parental endodermic branchial sac;[182] (ii.) that regenerated organs are by no means derivative of the blastemata whence they originally arose;[183] (iii.) that in the development of a familiar starfish the inner cells of the earliest segmentation stages, by intercalation among the outer, contribute half the fully formed blastula;[184] (iv.) that there are Diptera in existence in which, while it is well-nigh impossible to discriminate between the adult forms, there is reason to believe the pupa cases are markedly and constantly distinct; it becomes only too evident that the later embryonic and adult states are those most reliable for all purposes of comparison, and that it is by these that our animals can best be known and judged. Caution is, however, necessary with senility and age, since certain skulls have been found to assume at this period characters and proportions strikingly abnormal,[185] and by virtue of a most important discovery, which we owe to the Japanese, that in certain Holothurians, the calcareous skeletal deposits may so change with age, as to render specific diagnoses based on their presumed immutability invalid.[186] Advance, real and progressive, is in no department of zoological inquiry better marked than in comparative morphology, and it is for the pre-eminence of this that I would plead. Educationally, it affords a mental discipline second to none.

We live by ideas, we advance by a knowledge of facts, content to discover the meaning of phenomena, since the nature of things will be for ever beyond our grasp.

And now my task is done, except that I feel that we must not leave this place without a word of sympathy and respect for the memory of one of its sons, an earnest devotee to our cause. William Thompson, born in Belfast, 1806, became in due time known as 'the father of Irish natural history.' By his writings on the Irish fauna, and his numerous additions to its lists, he secured for himself a lasting fame. In his desire to benefit others, he early associated himself with the work of the Natural History Society, which still flourishes in this city. He was President of this Section in 1843, and died in London in 1852, while in the service of our Association, in his forty-seventh year, beloved by all who knew him. His memory still survives; and if, as a result of this meeting, we can inspire in the members of the Natural History and Philosophic Society of this city, as it is now termed, and of its Naturalists' Field Club, an enthusiasm equal to his, we shall not have assembled in vain.

List of References added after the Delivery of the Address, by desire of Friends.

[1] *Nature*, x. 362, and *Sci. and Culture*, p. 199. [2] Hirota, *Jour. Coll. Sci. Tokyo*, vi. 337. [3] Cf. *P.Z.S.*, 1896, p. 307. [4] Moore, *The Tanganyika Problem*, Lond., 1902. [5] *Cf.* Beddard, *Monogr. of the Order Oligochæta*, Oxford, 1895. [6] Beddard, *P.Z.S.*, 1893, p. 733. [7] Marsh, *Amer. Jour. Sci. and Arts*, iv. 15; xiv. 362; xlviii. 259. [8] *Cf.* Huxley, *Amer. Addresses*, 1877, p. 71; Marsh, *Amer. Nat.*, viii. 288; *Amer. Jour. Sci.* xvii. 497; Wortman, *Bull. Amer. Mus. Nat. Hist.*, viii. 81; Scott, *Jour. Morph.*, v. 301. [9] *Cf.* Scott, *op. cit.*, p. 364. [10] Osborn, *Bull. Amer. Mus. Nat. Hist.*, viii. 157; xvi. 91. [11] Cope, *Amer. Nat.*, 1884, pp. 1110, 1192; and 1885, p. 40. [12] Marsh, *Monogr. U.S. Geol. Survey*, vol. x. [13] Osborn, cf. *Bull. Amer. Mus. Nat. Hist.*, xiii. 229, and *Mem. Amer. Mus. N. H.*, i. 75. [14] Scott, *Trans. Amer. Phil. Soc.*, xviii. 125. [15] *Cf.* Osborn, *Bull. Amer. Mus. Nat. Hist.*, xvi. 169, and Wortman, *Amer. Jour. Sci.*, xi. to xiv. [16] Osborn, *Amer. Nat.*, 1893, p. 118; Osborn and Wortman, *Bull. Amer. Mus. Nat. Hist.*, v. 1. [17] Ameghino, *Enum. synopt. d. Mammif. Foss. d. f. éocène d. Patagonie*, Buenos Aires, 1894. [18] Scott, *Jour. Acad. Nat. Sci. Philad.* (2), pp. 9, 162. [19] Wortman, *Bull. Amer. Mus. Nat. Hist.*, vi. 129, and Osborn, *ibid.*, xiii. 269. [20] *Palæont. Rep. Princeton Sci. Expedit.*, New York, 1878, p. 57, Plate X.; *cf.* Scott, *Trans. Wagner Free Inst. Sci. Philad.*, vi. p. xi *et seq.* [21] Lydekker, *Palæontol. Argentina* (*Ann. Mus. La Plata*), ii. and iii. [22] *Ibid.* ii. part 2. [23] *Ibid.* iii. part 2. [24] Woodward, *Brit. Assoc. Rep.*, 1899, p. 783, and *P.Z.S.*, 1901 (1), p. 169. [25] Scott, *Science*, xv. 689. [26] Osborn, *Proc. 4 Internat. Congress Zool.*, 1899, p. 172; *cf.* Forsyth-Major, *Geol. Mag.* (4), vi. 547, and Andrews and Beadnall (*Saghatherium*) *Prelim. Note on some New Mamm. f. Upper Eoc. of Egypt*, Cairo, Nat. Printing Dept., 1902, 5. [27] Andrews, *Geol. Mag.* (4), viii. 437, 442. [28] Andrews and Beadnall, *op. cit.*, 1. (*Phioma*). [29] Andrews, *Geol. Mag.* (4), viii. 403. [30] *Ibid.*, p. 406. [31] *Ibid.* (4), ix. 291. [32] Beadnall, cf. *Nature*, lxv. 494. [33] *Cf.* Forsyth-Major, *P.Z.S.*, 1893, p. 196. [34] Huxley, *P.Z.S.*, 1880, p. 649. [35] Bresslau, *Zeit. f. Morph. und Anthrop.*, iv. 261. [36] Howes, *Jour. Anat. and Phys.*, xxiii 587. [37] Howes, *ibid.*, xxi. 190, and *P.Z.S.*, 1893, 585. [38] Hill, *Proc. Linn. Soc. N.S.W.* (2), x. and *Quart. Jour. Micr. Sci.*, xl. 385, and xliii. 1. [39] Van Beneden and Julin, *Archiv d. Biol.*, v. 369, and Hubrecht, *Quart. Jour. Micr. Sci.*, xxx. 283. [40] Symington, *Jour. Anat. and Phys.*, xxvii. 81. [41] Elliott Smith, *ibid.*, xxxv. 431, 448. [42] Ell. Smith, *P.R.S.*, lxx. 226. [43] Woodward, *P.Z.S.*, 1893, p. 450. [44] Ell. Smith, *Jour. Linn. Soc. Zool.*, xxviii. 446. [45] Broom, *P.Z.S.*, 1902 (1), 224. [46] Ell. Smith, *Trans. Linn. Soc. Zool.*, viii. part 12. [47] Earle, *Amer. Nat.*, 1897, pp. 569, 680. [48] *Cf.* Osborn, *supra*, ref. 15. [49] Woodward, *P.Z.S.*, 1899, p. 144, and 1900, p. 64. [50] Reinhardt, *K. Dansk. Vidensk. Selsk. Skr. Stockholm* (5), xii. 353. [51] Lankester, *Trans. Zool. Soc.*, xvi. 279, and Forsyth-Major, *P.Z.S.*, 1902, June and Nov. [52] Stirling, *Trans. R. Soc. S. Austr.*, 1891, p. 154. [53] Thomas, *P.Z.S.*, 1895, p. 870. [54] Huxley, *P.Z.S.*, 1882, p. 560. [55] Huxley, *ibid.*, p. 568. [56] Moser, Fanny. *Archiv f. mikr. Anat.*, lx. 587. [57] Marsh, *The Odontornithes: A Monogr. of the Extinct Toothed Birds of N. America*, Washington, 1880. [58] *Cf.* Andrews, *Geol. Mag.* (4), ii. 241. [59] Andrews, *Ann. and Mag. N. Hist.* (6), xv. 333. [60] Andrews, *Geol. Mag.* (4), iii. 1. [61] Dendy, *Quart. Jour. Micr. Sci.*, xlii. 1. [62] Howes and Swinnerton, *Trans. Zool. Soc.*, xvi. 14. [63] Andrews, *Ann. and Mag. Nat. Hist.* (6), xvi. 248. [64] Lydekker, *Brit. Mus. Cat. Fossil Rept. and Amphb.*, part 2, p. 78; *cf.* also Baur, *Anat. Anz.*, x. 456. [65] Newton, *Phil. Trans.*, 1888 B, p. 504; also Woodward, *Ann. and Mag. Nat. Hist.* (7), ix. 3. [66] Broom, *Trans. S. Afric. Phil. Soc.*, xi. 173. [67] Marsh, 'The Dinosaurs of N. America,'

Rep. 16th U.S. Geol. Survey, p. 177. [68] Boulenger, *Brit. Mus. Cat., Chelonia, Rhynchoceph., and Crocod.*, p. 17 *et seq.* [69] Originally by Brandt; *cf.* Pycraft, *P.Z.S.*, 1898, p. 974, and *Jour. Linn. Soc. Zool.*, xxviii. 343. [70] Dames, *Palæont. Abhand. Berlin*, ii. 144; *cf.* Osborn, *Amer. Nat.*, xxxiv. 777. [71] Froriep, *Archiv f. Anat. u. Phys.* (*Anat. Abth.*), 1882, p. 279, and 1885, p. 1. [72] Cf. *infra*, ref. 90. [73] Howes and Swinnerton, *supra*, ref. 62, p. 70. [74] Howes, *Nature*, xliii. 269 and *supra*, ref. 62, p. 69. [75] Osborn, *Mem. Amer. Mus. Nat. Hist.*, i. 179. [76] Seeley, *Phil. Trans.*, 1892 B, pp. 311, 364; *cf.* also Gadow, *Zeit. f. Morph. und Anthrop.*, iv. 345. [77] Riese, *Zool. Jahrb.* (*Anat. Abth.*), v. 99. [78] *Cf.* Boulenger, *P.Z.S.*, 1895, p. 402, and Kingsley, *Studies Biol. Lab. Tufts Coll. U.S.A.*, No. 7, p. 323. [79] Woodward, *Geol. Mag.* (4), iv. 293. [80] Credner, *Zeit. deutsch. geol. Ges.*, xiv. 639; also *supra*, ref. 62, p. 69. [81] Graham Kerr, *P.Z.S.*, 1898, p. 42; *Phil. Trans.*, B, cxcii. p. 304; 'Concerning *Protopterus*; cf. Günther,' *Proc. Linn. Soc.*, cxii. 60. [82] Ayers, *Jenaische Zeit.*, xviii. 480. [83] Boulenger, *Les Poissons d. Bassin d. Congo*, Bruxelles, 1901, p. 37. [84] Newberry, *Monogr.* 16, *U.S. Geol. Survey*; Woodward, *Brit. Mus. Cat. Fossil Fishes*, ii. pp. xxi, 276; and Bashford Dean, *Trans. N. York Acad. Sci.*, xv. 157; and *Mem.*, ii. part 3. [85] Newberry, *op. cit.*, pl. 44. [86] *Cf.* Collett, *Kgl. Norske Fred. Univ. Christiania*, Progr. 2nd Semester, 1897, and Woodward, *Ann. and Mag. Nat. Hist.* (7), iii. 487. [87] Traquair, *Mem. Palæontogr. Soc.*, 1877, and 1901, No. 2. [88] Traquair, *Ann. Scottish Nat. Hist.*, 1894, p. 94. [89] Traquair, *Trans. R. Soc. Edinb.*, xxxix., Nos. 20, 21, 32, and *Geol. Mag.* (4), vii. 153, and ix. 289. [90] Klaatsch, *Morph. Jahrb.*, xx. 143. [91] Günther, *Brit. Mus. Cat. Fishes*, viii. 512. [92] *Cf.* Ayers, *Biol. Lect. Wood's Holl.*, Boston, 1893, p. 137, Price K. Bayer, *Akad. d. Wiss.*, xxvi. 67 and Bashford Dean, *Quart. Jour. Micr. Sci.*, xl. 276. [93] Howes, *Proc. and Trans. L'pool Biol. Soc.*, vi. 122. [94] Ritter, *Brit. Assoc. Rep.*, 1895, p. 716. [95] Herdman, *supra*, ref. 93, p. 51. [96] Hatta, *Jour. Coll. Sci. Tokyo*, xiii. 311. [97] Howes, *Jour. Linn. Soc. Zool.*, xxiii. 555. [98] Budgett, *Trans. Zool. Soc.* xvi. 126. [99] Duméril, *Hist. Nat. des Poissons*, Paris, i. 38. [100] Woodward, *Brit. Mus. Cat. Fossil Fishes*, iv. pp. vii, 120. [101] Boas, *Morph. Jahrb.*, vi. 527. [102] Salensky, *Zool. Anz.*, i. 289. [103] Sewertzoff, *von Küpffer Festschr. Jena*, 1899, p. 281, and for general *résumé* and full reference see *supra*, ref. 62, p. 50. [104] Wheeler, *Psyche*, 1893, pp. 457–564, and *Jour. Morph.* iii. 369. [105] Hansen, *Entomol. Tidskr.*, xiii. 78, and Willey, *Zool. Results*, Camb., part 6, p. 704. [106] Hansen, *supra*, ref. 105, 71, and *Zool. Anz.*, xvi. 193, 201. [107] Cholodkowsky, *Mém. Acad. Imp. Sci. St-Pétersb.* (7), xxxviii., No. 4, p. 26. [108] Packard, *Zool. Anz.* xv. 229. [109] Pocock, *Zool. Anz.* xvi. 271. [110] Dendy, *Quart. Jour. Micr. Sci.*, xlv. 363. [111] Hansen, *The Choniostomatidæ*, Copenhagen, 1897. [112] Hansen, *Ergeb. d. Plankton-Exped. d. Humboldt-Stiftung*, Kiel und Leipzig, ii. 49. [113] Thomson, *Trans. Linn. Soc. Zool.* (2), vi. 285; also Calman, *T.R.S. Edinb.*, xxxviii. 787. [114] Calman, *Jour. Linn. Soc. Zool.*, xxvii. 338. [115] Sayce, *Ann. and Mag. Nat. Hist.* (7), viii. 558. [116] Huxley, *P.Z.S.*, 1878, p. 752. [117] Claus, *Arb. Zool. Inst. Wien*, vi. 42; Hansen, *supra*, ref. 106; *cf.* also Calman, *supra*, ref. 113, 793. [118] Beecher, *Amer. Jour. Sci.* (4), i. 251; *Amer. Geol.*, xvii. 303. [119] Beecher, *Amer. Jour. Sci.*, xlvii. 298. [120] Nusbaum, *Archiv Zool. Exp.* (2), v. 161. [121] Bumpus, *Zool. Anz.*, xvii. 176. [122] *Cf.* McMurrich, *Biol. Lect. Wood's Holl. Boston*, 1891, p. 79. [123] *Cf.* espec Meisenheimer, *Zeit. wiss. Zool.*, lxix. 114. [124] Lacaze-Duthiers, *Hist. du Dentale*, Paris, 1858, p. 216. [125] Drew, *Anat. Anz.*, xv. 493; *Mem. Biol. Lab. Johns Hopkins Univ.*, iv., No. 3, and *Quart. Jour. Micr. Sci.*, xliv. 313. [126] Pruvot, *Comptes rendus Acad. Sci. Paris*, cxi. 689. [127] Häcker, *Zeit. wiss. Zool.*, lxii. 101. [128] Borradaile, *P.Z.S.*, 1901 (ii.) 714, figs. 5, 6. [129] Pelseneer, *Archiv d. Biol.*, xi. 287. [130] Pelseneer, *Archiv d. Biol.*, xvi. 99; *cf.* also Lovén, *Archiv f. Naturgesch.*, 1856, p. 206. [131] *Ex. Myacea*, and *cf.* Lacaze-Duthiers, *supra*, ref. 124, Pl. VII., fig. 6. [132] Patten, *Arb. Zool. Inst. Wien*, vi. 149. [133] Hatschek, *ibid.*, iii. 11. [134] McMurrich, *Studies Biol. Lab. Johns Hopkins Univ.*, iii. 433. [135] Semper, *Zeit. wiss. Zool.*, xxii. 311, and Bütschli, *ibid.*, xxvi. 395; *cf.* Thorpe, *Jour. R. Micr. Soc.*, 1891, p. 301; 1893, p. 147; and Kofoid, *Science*, iv. 935. [136] Bouvier, *Comptes rend. Acad. Sci. Paris*, cxvi. 68; and Plate, *Zool. Jahrb.* (*Anat. Abth.*), ix. 200. [137] *Cf.* Woodward, *Quart. Jour. Micr. Sci.*, xliv. 215, and Fleure, *ibid.*, xlvi. 77. [138] Ex. *Ampullariidæ*, Bouvier, *Ann. Sci. Nat. Zool.* (7), iii. 100 *et seq.* [139] Pelseneer, *Comptes rend. Acad. Sci. Paris*, cxix. 354. [140] Girard, *Jour. Sci. Acad. Lisbon*, (2), iv. 28. [141] *Cf.* Crick, *Proc. Malac. Soc.*, v. 15. [142] Moore, *supra*, ref. 4; and *Jour. R. Geogr. Soc.*, 1901, p. 1. [143] *Cf.* Day, *Fishes of India*, Pl. CXCIII., figs. 1 and 2, and Pl. CXCIV. [144] Fritsch, *Die elect. Fische*, Leipzig, 1887, and *Nature*, xlvii.

271; *cf.* also Ewart, *Phil. Trans.*, 1888 B, pp. 399 and 539. [145] Stejniger, *Proc. U.S. Nat. Mus.*, xviii. 620; and cf. *Nature*, lx. 389. [146] Huxley, *Anat. of Invert. Anim.*, pp. 645, 671; *cf.* Savile Kent, *Ann. and Mag. Nat. Hist.* (5), ii. 68, and Lankester, *Quart. Jour. Micr. Sci.*, xix. 476. [147] Pocock, *Ann. and Mag. Nat. Hist.* (7), ix. 256. [148] Patten, *Quart. Jour. Micr. Sci.*, xxxi. 317; and *Amer. Nat.*, xxxvi. 379. [149] Patten, *Verh. 5 Internat. Zool. Congresses*, Berlin, 1902, p. 183; *cf.* Lindström, *Bih. til k. Svensk Vet.-Akad. Handl. Stockholm*, xxi., Af. 4, No. 3. [150] Traquair, *supra*, ref. 89. [151] Gaskell, *Brit. Assoc. Rep.*, 1896, p. 942. [152] *Quart. Jour. Micr. Sci.*, xxxi. 402. [153] *Jour. Anat. and Phys.*, xxxv. 224; xxxvi. 164. [154] Cf. *Proc. Camb. Phil. Soc.*, 1895, 19. [155] Owen, *Todd's Cyclop. of Anat. and Phys.*, i. art. 'Cephalopoda.' [156] Lacaze-Duthiers (and Delage), *Mém. Acad. d. Sci. Paris*, xlv., No. 1, pp. 8, 9. [157] Lankester, *Quart. Jour. Micr. Sci.*, xxi. 504, 609, and article 'Arachnida,' *Encyclop. Brit.*, ed. 10, p. 519. [158] Holm, *Mém. Acad. Imp. Sci. St-Pétersb.* (8), viii. No. 2, Pl. III., figs. 1, 2, 5. [159] Laurie, *Trans. Roy. Soc. Edinb.*, xxxix. 586. [160] *Cf.* also *Polyphemus*, Zacharias, *Zeit. wiss. Zool.*, xli. 252. [161] *Cf.* Wheeler, supra (*Jour. Morph.*), ref. 104, and Spencer, *Quart. Jour. Micr. Sci.*, xxv. 183. [162] Bernard, *Jour. Linn. Soc. Zool.*, xxiv. 426. [163] Michael, *Brit. Oribatidæ, Ray. Soc.*, i. 168. [164] Hansen, *Entom. Medd. Stockholm*, 4B, p. 198. [165] *Cf.* Lankester, *Quart. Jour. Micr. Sci.*, xxv. 339, and Simmons, *Tufts Coll. Studies*, ii. 49. [166] Hansen, *Entom. Tidskr.*, 1901, p. 208. [167] *Cf.* Lankester, *Quart. Jour. Micr. Soc.*, xxiv. 140; and Hartog, *Trans. Linn. Soc. Zool.* (2), v. 44. [168] *Cf.* Lankester, *supra*, ref. 167, 129; and Stewart, *Cat. Physiol. Ser. R. Coll. Surgeons*, ed. 2, i. 18. [169] Lankester, ref. 157 (*Quart. Jour.*) Pl. XXIX., figs. 5, *5a*; Patten and Redenbaugh, *Jour. Morph.* xvi., Pl. II., figs. 11, 12. [170] *Cf.* Pocock, *supra*, ref. 147, 266. [171] Bernard, *Trans. Linn. Soc. Zool.* (2), vi. 308. [172] Hansen and Sorensen, *Entomol. Tidskr. Stockholm*, 1897, p. 223. [173] For references see Pocock, *Quart. Jour. Micr. Sci.*, xliv. 291. [174] Beecher, *Geol. Mag.* (4), viii. 561. [175] *Cf.* Woodward, *Palæontogr. Soc. Monogr.*, part 4, 1872; Schmidt, *Mém. Acad. Imp. Sci. St-Pétersb.* (7), xxxi. No. 5, and Beecher, *Geol. Mag.* (4), vii. 481. [176] Holm, *supra*, ref. 158, Pl. II., fig. 1. [177] *Cf.* especially Thorell and Lindstrom, *Konigl. Vet.-Akad. Handl. Stockholm*, xxi., No. 9, fig. 1. [178] Pocock, *supra*, ref. 147, 265. [179] *Cf.* Bate, *Rep. H.M.S. Challenger*, xxiv. 503, and Bate and Westwood, *Hist. of Brit. sess-eyed Crustac.*, Lond., p. 45. [180] *Comptes rend. Acad. Sci. Paris*, lix. 710; for fig. *cf.* Howes, *P.Z.S.*, 1887, p. 469. [181] Herbst, *Archiv f. Entwick-mechanik*, ix. 215, and Hofer, *Verhand. deutsch. zool. Gesellsch.*, 1894, p. 82. [182] Wilson, *Biol. Lect. Wood's Holl.*, Boston, 1895, p. 111, and Ritter, *Science*, v. 435. [183] *Ex.* 'The Regenerate Lens of Triton,' Colucci, *Mém. Acad. Bologna* (5), i. 167, and later Müller, *Archiv f. mikr. Anat.*, xlvii. 23. [184] Masterman, *T.R.S. Edinb.*, xi. 380. [185] Thomas, *P.Z.S.*, 1886, p. 125. [186] Mitsukuri, *Annot. Zool. Japonenses*, Tokyo, i. 31.

The following Papers and Reports were read:—

1. *On British Fisheries' Investigations and the International Scheme.*
By Professor W. C. McIntosh, *M.D.*, *F.R.S.*

Before referring to the proposals for the International Scheme of Fisheries' Investigations in the North Sea, the history of Fisheries' Investigations in our country may be noticed. Few of note occurred before 1883, and more real progress had been made in regard to the Salmon than the Sea Fisheries, mainly because individual effort could be carried further in the former than the latter. Yet it was rather a lack of opportunity than of interest which was responsible for this condition of things. The Royal Commission of 1883, presided over by Lord Dalhousie, made the first attempt to grapple with the scientific aspects of the question, and a series of observations were carried out by the same eye and embodied in the Report. One result was that a scheme was drawn up, three areas of the sea closed, and arrangements made for a series of test-experiments upon which future legislation—including closures—was to rest. The important duty of carrying out these experiments was entrusted to the Scotch Fishery Board, and special instructions were given as to the kind of ship and the kind of trawl necessary for their success. Unfortunately, the Scotch Board followed methods of its own, so that instead of continuing and extending the observations of 1884, a new set was begun, a set which could be compared with nothing which had been done previously, which was then being done, or which would be done in future. The Scotch Board, however, did not wait for some decisive results of these experiments, but proceeded to close areas and present a Report of its own—which, briefly, was to the effect that a considerable increase had occurred in the fishes of the areas closed, and therefore it recommended further closures, and this notwithstanding the inefficiency of the ship the Board had selected for the experiments. After ten years' experiments with the same unreliable ship, the Board came to the conclusion that, while round fishes had kept up their numbers, flat fishes had diminished in the closed areas from the excessive trawling in the regions beyond the three-mile limit. Consequently, it looked for important results from its experiments in the vast area of the Moray Firth, which has been closed for ten years. It is to be regretted, however, that the closure of this great off-shore area has produced no other result than is shown in the following quotation from the Board's Report for 1900[1]: 'The quantity of fishes procured by the *Garland* is therefore small, and furnishes a most inadequate basis for any conclusions as to the effect of the closure of so wide an area as the Moray Firth. The incompetence of the vessel for the work it was intended to perform—from other reasons than its unseaworthiness—has been frequently pointed out in previous reports.' It is seldom that so candid an admission is made (1) of the mistake of purchasing such a vessel; and (2) of the validity of the criticisms in the 'Resources of the Sea.' Whilst these remarks are made, it has to be borne in mind that the early impressions of the Board, viz., that the closure of an area increased its fishes, probably led to misapprehensions. Even if it had been practicable to prove this, the methods and materials were inadequate. Fisheries have been as variable in the olden time as now, and wherever long-continued and accurate observations have been carried out the reasons brought forward in support of the impoverishment of the sea are found to be slender.

A careful survey of the mode in which the important scientific observations entrusted to the Scotch Department have been carried out does not inspire confidence.

Certain proposals for the improvement of the Fisheries, as well as those of the International Scheme of Fisheries' Investigations, may now be considered.

Foremost amongst the former is the necessity for improved statistics. In Scotland the records now show what certainly has been taken, but it is doubtful if all that has been taken is recorded. The present incomplete state of the statistics of the fisheries in England and in Ireland is much more clamant. In dealing with the statistics of the fisheries of the United Kingdom, therefore, as a basis on which to urge expensive and important measures, great caution is required, and this especially applies to the international scheme.

A necessity exists also for the careful survey of the off-shore and in-shore fishing-grounds. The close relation between these has frequently been pointed out since 1884 onwards. The life-histories of the food-fishes would thus be advanced, and the ambiguities connected with the use of such a term as 'nurseries of plaice' dispelled.

But, besides the ordinary off-shore fishing-grounds, the conditions still farther from land are important. If, as the writer has often said, the food-fishes, or certain of them, stretch far outwards on both shores of the Atlantic, the closure of the tiny strip of three miles round the shores of Great Britain is insignificant.

Such investigations should be undertaken by the central authority, for the sea, with its pelogic contents, is not the property of a local committee, but is the property of the nation.

In the international scheme hydrographical work occupies a prominent position, yet hitherto the results of meteorological, hydrographical, and other physical investigations in connection with the sea-fisheries have not been of such promise as to warrant their being placed in the foreground. The statement that it is probable that changes in the water in the North Sea must profoundly affect the fishes has yet to be proved. When one reflects that the ways and methods of fishes and the forms on which they feed in the ocean and in the North Sea in particular have been for ages as they are, and probably as they will be for ages yet to come, this appeal for hydrography, under present circumstances, can scarcely be admitted. Irrespective of currents—whether Arctic or Atlantic—the very young fishes invariably follow the laws which regulate their appearance at particular seasons. Hydrographical and other physical work should be relegated to the trained officers on board H.M. ships, and thus relieve the present scheme. These remarks are not intended to depreciate the value of meteorological and hydrographical work as a field for scientific research.

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[1] Part III., p. 19, 19th Report, 1891.

In the programme of the International Conference the food of fishes is included under general faunistic work. This is unnecessary, for the ocean teems with nourishment at all seasons.

Though not specially recommended, the subject of the artificial propagation of marine fishes is mentioned under Clause III. This subject is at present on its trial. No result of importance has yet been achieved by the Scotch Fishery Board after eight or nine years' labours and expenditure. In some cases it would appear that the transportation of the adults (*e.g.*, soles and plaice) to the region to be experimented with would be more satisfactory; as, indeed, was shown at St. Andrews in the case of the sole, eight or nine years ago.

In dealing with the exploration of the fishing-grounds, it is well to note what has recently been accomplished in Norway. Dr. Johan Hjort and Dr. Knut Dahl have found immense numbers of young gadoids (chiefly cod and haddock) in the vast area stretching from the shores of Norway to Iceland and Jan Meyen. This is corroborative of the opinions held by the author, and of those expressed here. From a fisheries' point of view the distribution of the important food-fishes, such as the cod, haddock, ling, hake, plaice, turbot, brill, and sole, is of the first importance in the international scheme, for it is clear, if their habitat embraces much of the Atlantic, pigmy measures of closure in the North Sea are of little moment in the interests of the fisheries. On the other hand, the practical treatment of the immature-fish question should not be a leading motive for the participation of Great Britain in the International Conference.

The scheme of the Conference leaves out the determination of the distribution and other features of the food-fishes to the W. of about 10° W. off the greater part of the British coast, whilst the only parts coming within its influence are the eastern and western coasts of Scotland. The Danish areas also are too limited. The determination of the seasonal changes in these limited areas, as regards temperature, solenity, currents, food-supply of fishes, eggs, larvæ, young and adult food-fishes, is not of vital importance. Arrangements, moreover, are only made for the working of the new steamers in Scottish waters. It is doubtful if other available aid will suffice.[1]

Again, it would have been well to make the life-history of the salmon in the sea a definite subject of inquiry. This would be greatly aided by the systematic marking of smolts and salmon, as Mr. Holt and Mr. Calderwood are now doing.

In regard to the institution of a central body or department for the three divisions of the kingdom, it may be remarked that this was Lord Dalhousie's idea. It presents simplicity in administration, economy in the staff and offices, uniformity in statistics, freedom from local influences, and a wider field for deduction. Yet it may be questioned whether the vast area and its complex and ever-varying details could thus be efficiently handled.

In the case of separate administrative departments in England, Scotland, and Ireland, each would more readily adapt itself to the wants of the countries. The present staff in each country would require reorganisation.

In considering the question of assistance from the State in fisheries' researches, it would appear to be prudent that all such assistance should be given by the Fisheries Authorities (such as the Fishery Board for Scotland in its re-modelled form). One, or at most two, marine laboratories efficiently supported and energetically administered, are sufficient for each division of the country. 'Adequate scientific investigations' is a term capable of various interpretations as a basis for legislation. Experience shows that the most extended and the most complete series of investigations in regard to special areas—viz., those of the Scotch Fishery Board, by means of the *Garland*—were not followed by legislation on the lines of the results.

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[1] Certain changes, which indicated uncertainty in the original programme, appear to have been made at the recent Conference.

The members of the three separate Boards should be representative of the various fishing interests, of legal knowledge and of scientific experience in the fisheries, the advice of the Royal Society being taken in regard to the latter.[1] Each Board should have one efficient ship, a well-equipped marine laboratory, or two where these already exist, and a small but efficient staff of scientific workers. The Boards should be in constant touch with each other so as to avoid duplication. They should retain the control of the scientific fisheries' researches, the necessary organisation for each, and the collection of statistics. District committees would be useful in the management of oyster and mussel beds, cockle-grounds, and similar departments, but all scientific work in connection even with these, and on the salmonoids, should be under the authority of the central Boards.

Finally, and above all, it must be clearly understood that the most expensive, most complete, and most skilfully conducted international surveys cannot alter the laws of Nature, or cause the sea to hold a larger number of food-fishes at a given time than the circumstances of capture and other conditions warrant. Great and fortuitous variations have occurred, now occur, and will occur, in the abundance of all marine food-fishes. Nothing more may accrue from the most searching inquiry. This caution is the more necessary in view of the readiness of the Government to launch into the somewhat expensive undertaking of the international scheme. Yet there is no fear of the extinction of any species of food-fish, especially of those important to man. Furthermore, fishes have abounded in the primæval as in the modern seas, although the ravages of the gigantic reptilian and other fish-destroyers, which in some cases were distributed over the whole expanse of the ocean, could not have been less than even the far-reaching methods of man. In neither period has extinction ensued from the prevailing agencies, nor is it likely to take place under these conditions in the future.

2. *The International Investigation of the North Sea.*
By WALTER GARSTANG, *M.A.*

3. *Certain Objections to the Proposed Scheme of International Investigations of the North Sea.* *By* D. NOËL PATON, *M.D., B.Sc.*

To Great Britain, with its preponderating interest in the fisheries of the North Sea, the most important point to be determined by a scientific investigation of that area is whether there is or is not a decrease in the number of fish.

The question considered in the paper is 'how far the proposed scheme of international investigation is calculated to give information of value upon that point.'

It is indicated that the work is to be done by a comparatively small number of steamers working along certain lines, and that this implies—

1st. That conclusions as to the general distribution of fish are to be drawn from samples taken from limited areas.

2nd. That the take per ship—or per capturing unit—is to be adopted as the means of measuring the abundance or density of the fish.

The available evidence as to how far the adoption of these methods is justifiable is considered.

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[1] The Government has in its present scheme entirely avoided the Royal Society.

1st. It is shown that the analysis of the Frith of Forth investigations published in the Sixteenth Annual Report of the Inspector of Fisheries ('Sea Fisheries: England and Wales') indicates that the results as to the number and size of fish captured in any one area may diverge widely from those obtained in closely adjacent areas. It would thus appear that it is fallacious to draw conclusions from such small samples as can be procured by the method to be adopted in the proposed scheme.

2nd. It is pointed out that the take per capturing unit varies with the number of capturing units at work as well as with the density of the fish, and that, therefore, it is fallacious to accept it as a measure of the latter. This is illustrated by the example of the effect of increasing the number of bag nets in a range of nets on the take of salmon per net. It is pointed out that the majority of the Norwegian Commission on Salmon Fisheries fell into this error of accepting the take per net as a measure of the abundance of salmon, and that Mr. Garstang, in his 'Impoverishment of the Sea,' also made the same mistake. His Grimsby figures are analysed, and it is shown that they do not justify his conclusion that a decrease in the number of fish is proved by them. It would therefore appear that to accept the take per unit as a measure of the abundance of fish is fallacious and likely to yield unreliable results.

The danger of allowing international investigations, which may be expected to lead to legislation for the regulation of our fisheries, to be carried out by such unsatisfactory methods is strongly urged.

4. *The Scales of Fishes as an Index of Age.*[1] *By* J. STUART THOMSON.

This paper took the form of a lantern demonstration illustrating the new method of determining the age of Gadoid fishes by means of their scales.

The scales of Gadoid and many other fishes show a series of parallel eccentric lines which indicate successive increments of growth. These lines of growth have been found to be more widely separated in that part of the scale formed during the warm season of the year than in the portion formed during the cold season; the alternation of the two series gives rise to the appearance of 'annual rings' which indicate the age of the fish in years.

5. *Report on the Migration of Birds.*—See Reports, p. 273.

6. *Report on the Occupation of a Table at the Zoological Station, Naples.* See Reports, p. 259.

7. *Report on the Occupation of a Table at the Marine Biological Laboratory, Plymouth.*—See Reports, p. 271.

8. *Report on the 'Index Animalium.'*—See Reports, p. 283.

9. *Twelfth Report on the Zoology of the Sandwich Islands.* See Reports, p. 284.

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[1] The paper will be published *in extenso* in the *Journal of the Marine Biological Association.*

10. *Third Report on the Coral Reefs of the Indian Region.*
See Reports, p. 284.

11. *Interim Report on Researches made in the Laboratory of the Marine Biological Association of the West of Scotland, Millport.*

FRIDAY, SEPTEMBER 12.

The following Papers were read:—

1. *Account of his Recent Expedition to the Indian Ocean, including Work on the Pearl Oyster Banks of the Gulf of Manaar. By* Professor W. A. Herdman, *F.R.S.*

2. *On the Amphipods collected by Professor Herdman.*
By A. O. Walker, *F.L.S.*

The collection is contained in about sixty tubes of which I have only had time to examine one. From this I sorted out what I take to be fourteen genera belonging to twelve families. I have no doubt that the collection will prove to be the most important yet received from tropical seas. Although the species will no doubt be different from those of our shores, yet the general character of those examined did not appear to differ greatly from what one would expect to take in five to ten fathoms on our shores; but this statement may have to be modified on further examination. In point of size they do not appear to differ much from species of the same or allied genera on our own coasts.

The only species identified is *Melita cotesi*, Giles, the male of which is remarkable for having the hand of one of the second pair of limbs enormously developed, and the distal margin armed with three teeth. As the colour of the limb is pink, the resemblance it bears to a broken bit of shell is very close. The leg on the other side is slender and feeble. The use of this limb appears to be protective, as Dr. Herdman says the animal buries itself in the sand, covering itself with it. The female, however, has no such protection, the second pair of legs being equal and slender. I may add that I have seen a species common on our shores carry a piece of shell when swimming, under which it hides when at rest.

3. *On the Plankton of the Indian Ocean. By* Isaac C. Thompson, *F.L.S.*

The plankton or general surface material collected by Professor Herdman during his recent voyage to Ceylon and while there, was entrusted to me for examination. It was contained in fifty-five bottles of three ounces capacity each; the preservative material used was in some cases formol and in others alcohol. Ten of the bottles contained material collected from Liverpool to the south end of the Red Sea, fourteen bottles from the Indian Ocean, and thirty-one bottles from the Ceylon district, including the pearl banks and the coral reefs. Passing over the first-mentioned series I proceed to deal with the material contained in the fourteen bottles collected in the Indian Ocean. Professor Herdman's method of collecting material while travelling in a rapid mail-steamer has been described in the 'Proceedings' of the Liverpool Biological Society. On this occasion he was fortunate enough to have the entire use of one of the bath-rooms. Water was drawn from about 12 feet below the surface of the sea into a tank on the ship from which baths, &c., are supplied. A tow-net was fixed to the tap, so that all the supply of water ran through it; by this means it was practicable to collect the material contained in the water mostly in good condition from the whole length of the route travelled. The material obtained was necessarily restricted to that taken from a depth of about

12 feet below the surface; if that from a greater depth or from the actual surface could have been obtained, a much larger variety of fauna would have been secured. The plankton obtained was very varied. Diatoms (Coscinodiscus, Biddulphia, &c.), Foraminifera (Globigerina), minute Algæ (Peridineæ, Ceratium, &c.), Medusæ, Pteropods, Radiolaria, Crustacea (Erichthius, Stomatopods, Amphipods, Cirripeds), Salpæ, &c.

By far the largest proportion of the ocean plankton secured consists of Copepoda, a division of the Entomostraca, and I devoted my examination mainly to this class. The amount of plankton taken by tow-net at different places was very unequal, and depended upon atmospheric conditions—light, heat, cold, calm, or tempest greatly influenced it. From causes difficult to explain, the tow-net was sometimes almost empty; at other times it contained masses of one class of life, the other forms probably having gone to a greater depth. Copepoda are the commonest, and the most widely distributed of all marine life, often constituting the entire mass taken by the tow-net. Many of the surface species are buoyed up by their internal oil-globules, as in the Arctic Seas, where one species (*Calanus finmarchicus*), hardly one quarter inch long, of red colour, is said to form the sole food of the Greenland whale. Most of the bottles contained several thousands of animals, many of which required to be dissected with finely pointed needles under the microscope for the determination of their species. In the fourteen bottles taken in the Indian Ocean I found sixty-four species of free swimming Copepoda, comprising twenty-seven genera, many of which had not been previously known in the Indian Ocean, and probably some new species not yet determined. As might be expected, they are mostly free swimming non-parasitical forms belonging chiefly to the families Calanidæ, Pontellidæ, Cyclopidæ, Corycæidæ, and Sapphirinidæ. Swarms of one species sometimes occur in a particular gathering. In this connection I may allude to *Trichodesmium erythræum*, a minute reddish-brown Alga mentioned in 'Darwin's Voyage of the "Beagle,"' and common in the Red Sea, which nearly fills one bottle collected off the Ceylon pearl banks. When the Ceylon material comes to be examined it may probably be found widely distributed. We shall have a fairly complete record of the plankton taken from the entire route traversed when the whole collection is examined.

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4. *On the Cuttlefishes collected by Professor Herdman.*
By W. E. Hoyle, *M.A.*

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5. *On Deposits dredged by Professor Herdman in the Indian Ocean.*
By J. Lomas, *A.R.C.S., F.G.S.*

The samples of sea bottom, about thirty in number, were collected mainly from four districts round the coasts of Ceylon, S. of Ceylon about Point de Galle, the E. coast at Trincomalee Bay, Palk Bay N. of Ramiserram and Adam's Bridge, and the Gulf of Manaar.

In Galle Bay, from depths of 6 to 8 fathoms, shells with sand were dredged. Large drifted shells, such as Arca, Anomia, Ostrea, Cucullæa, and Turritella, mostly in a rotten condition, made up the bulk of the coarse material, along with large barnacle valves and a few sharks' teeth. Encrustation of Nullipores, Serpulæ, and Polyzoa covered the shells, and Cliona borings were common in those shells composed of calcite, while aragonite forms were not affected.

The finer material, obtained by sifting through a sieve with a mesh of 1 mm., contained from 61·41 to 62·52 per cent. of carbonate of lime, and included small Molluscs, echinoid spines, plates and anchors of Holothurids, spicules of Alcyonium and Leptoclinum, as well as many Foraminifera, such as Heterostegina, Globigerina, Textularia, and Spiroloculina, fragments of Molluscs, Crisia, and Nullipores, and as inorganic constituents kyanite, corundum, zircon, rutile, tourmaline, mica, and quartz. A considerable amount of coal, in pieces up to ¾ inch in diameter, well rolled, may be due to accidental causes.

From off Belligam two samples were dredged, one, a fine calcareous mud with shells, yielding 76·50 per cent. of carbonate of lime, and another, obtained at depths of 4 to 6 fathoms, containing many rotten brown shells bored by Cliona, Barnacle valves, and Halimeda in fresh condition.

The fine material in both hauls consists of smooth mud which cakes on drying. It contains very few quartz grains. Foraminifera are rare, but spicules of Sponges, Ascidians, and Holothurians make up the bulk of the non-calcareous matter. Diatoms, especially Coscinodiscus, are fairly abundant.

Off the mouth of Trincomalee Bay, at 12 fathoms, Foraminifera sand was dredged containing 67·7 per cent. of one form, Heterostegina. Mollusca, including such forms as Arca, Trochus, Patella 4·8 per cent., Corals and Polyzoa 0·2 per cent., Nullipores 8·0 per cent., while Alveolina (two species) make up 0·9 per cent. Echinocyamus occurs sparingly: 16·5 per cent. passed through the fine sieve, and this material consists almost entirely of Foraminifera, including Pulvinulina, Textularia, Discorbina, Miliolina, and Nummulites. Pteropods, Alcyonium, and Sponge spicules are fairly plentiful. The inorganic constituents include quartz grains, well rounded and ranging up to 3 mm. diameter, and a black powder much of which could be removed by a magnet. The non-magnetic portion was fractionated by means of the double iodides of mercury and barium, and showed a great number of garnets, corundum, tourmaline, and kyanite in the heavier fractions, while quartz and a few flakes of mica made up the lighter portions.

North of Ramiserram, in Palk Bay, where shallow water (6 to 7 fathoms) conditions extend over a great area, and where there is an almost complete absence of currents, a very extraordinary deposit occurs: it consists mainly of concretions, irregular in form, with here and there a cast of shell along with a few large shells in a fairly fresh but broken condition. The shells include Arca, Cardium, Modiola, Chama, Pecten, Murex, Nassa, and the Pearl Oyster. No double valves are found and the calcite varieties are sometimes bored by Cliona. No fine material accompanies the deposit. The concretions, however, on treatment with a weak acid effervesce strongly and yield a large percentage of fairly coarse sand. The casts, which yield 64·80 per cent. of carbonate of lime and 2·2 per cent. of phosphate of lime, fall to mud when placed in water, and it was necessary to soak in thin balsam and harden before a section could be obtained. Round the periphery of the casts is a fine layer of calcite, which moulds itself into the inequalities of the shell's inner surface: this is succeeded by a darker layer, and then the whole interior is seen to consist of sand grains, quartz, tourmaline, felspar, and zircon, embedded in a mass of secondary calcite. The sand grains increase in size on proceeding from the exterior inwards, and remind one of the well-known fact that when grains of different dimensions are shaken in a basin the finer material sinks to the bottom and the coarser rises to the surface. It is probable then that the grains were rocked to and fro when in a loose condition inside the shell and the cementing took place subsequently. Afterwards, owing to altered conditions, the outer shell was dissolved and the cast left. It is noteworthy that felspars are found in these casts, while they are absent, as a rule, from sea sands. They must have been embedded very soon after their breaking away from the parent rocks and before kaolinisation had reduced them to clay.

The inorganic fragments dissolved out by acids and fractionated showed a great preponderance of garnets. The heavier portions were pink in colour on this account. Other minerals found were corundum, tourmaline, zircon (inclosed in garnet and free), kyanite, quartz, mica, and felspar. A number of black grains were composed of ilmenite.

Farther east, and just north of Adam's Bridge, at a depth of 7 fathoms, a fine black mud occurs, which on analysis gives:—

Water and Organic Matter . . .	16·60	per cent.
Silica	55·00	„
Carbonate of Lime	3·50	„
Phosphate of Lime	2·25	„
Ferric Oxide	4·10	„
Alumina	15·80	„
Magnesia	2·75	„

A few heavy minerals occur, but the bulk is made up of clay with minute grains of quartz. Only a few organisms, one Foraminifera, and a small shell fragment were found in a sample examined.

In the Gulf of Manaar banks are found which shallow towards the middle of the bay and deepen towards the north and west.

The middle area of these banks consists mainly of sand yielding carbonate of lime from 3·09 to 7·04 per cent. On the margins, where shell fragments and Foraminifera become more abundant, the percentage increases to 22·20 and 34·32; while on the extreme west, where depths of 80 fathoms are found, the amount becoms 76·50 and 85·86 per cent. Some range up to 92·05 and even 95 per cent. of carbonate of lime.

The sands of the central area include as a rule a high percentage of heavy minerals, but very little is found in the more calcareous samples. In the Foraminifera sands Heterostegina is exceedingly abundant. It is accompanied by simple corals such as Heteropsammia, Polyzoa, Pteropods, the spat of young Oysters, Echinocyamus, Nullipores, a red branching Foraminifera like Polytrema, and Diatoma.

On the west coast, south of Chilaw, at 8½ fathoms, the dredge brought up enormous quantities of Nullipores of a white or greyish colour. These were mostly globular in form and ranged up to 2 inches in diameter. On breaking, the interior was in many cases red in colour. Sections of these showed fresh growth of the plant on the outer margin and broken-down tissue in the interior. Imbedded in the plant structure were numerous sand grains consisting of quartz, garnet, tourmaline, and magnetite. While these inclusions mostly occur in lines they show no selection of grains into sizes. They have probably been inclosed by irregular growth on the part of the Nullipore, and some may have filled the crypts formed by Lithodomus borings. The breaking up of the tissues and oxidation of the ferruginous grains account for the red staining of the interior.

One or two points may be mentioned regarding the deposits as a whole:

1. Some, such as in Galle Bay and Palk Bay, are evidently very old. They represent the remains of a fauna where solution and chemical changes have been at work. The shells left are mostly composed of calcite, not aragonite, and chemical analysis shows that many of the shells have become partially converted into phosphate of lime.

2. In all the cases where Sponges like Cliona have bored into shells they are calcite, not aragonite. It would not be safe to assert that Cliona never bores into aragonite, but it certainly holds good in those specimens I have examined both from the Indian Ocean and other places.

3. The inorganic minerals which are found in all the deposits such as quartz, garnet, kyanite, &c., are stable, and resist dissolving agents. The fact that other less resistant minerals are found in casts of shells leads to the conclusion that these may have been removed since the sands were laid down.

4. In drifted deposits a relation exists between the size or weight of the inorganic and organic constituents. Where large shell fragments are found large minerals also occur. This fact might be useful in determining cases where other evidence of drifting is not conclusive.

My thanks are due to Professor Herdman, who has helped me in the determination of some forms, and to Mr. C. C. Moore, F.I.C., for the care he has taken in analysing the deposits.

6. *Notice of a hitherto unrecorded Element in the Occipital Bone of Seals.*

By Professor CLELAND, *F.R.S.*

I have long been aware of the bony element which I now show in the skull of a young hooded seal, *Stemmatopus cristatus*. It corresponds exactly with the paroccipital of Owen in osseous fishes. It articulates behind with the broadest part of the supraoccipital, in front with the mastoid, above with the parietal, and below with the lateral element of the occipital bone called exoccipital by Owen. I have not hitherto called attention to it because I waited till I could find out if it occurred in seals generally. Sir William Turner has given me the opportunity of investigating this point, and in specimens in his possession I have along with him seen the element in question distinct in *Phoca barbata*, *P. groenlandica*, *P. vitulina*, *P. hispida*, and *Halichœrus grypus*; also in *Otaria jubata* and *Arctocephalus ursinus*. In a young walrus I can make out the exact extent of the corresponding portion of bone, but in my specimen no indication is afforded of separate ossification. I attach great importance to this osseous element in the seals, as it adds a very important argument in addition to the other evidences that the paroccipital of the fish is a true occipital element, and that the mastoid recognised by Cuvier and Owen in the fish is homologous with the mastoid of the mammal, and that in these matters Huxley was in error.

7. *On the Habits of the Predaceous Flies of the Family of Asilidæ.*
By Professor E. B. Poulton, *F.R.S.*

8. *The Development of the Common Sea-urchin* (Echinus esculentus).
By Professor E. W. MacBride, *D.Sc.*

The paper concerned the results of an investigation which had been carried on for the last four years. The difficulty of rearing the larvæ was first pointed out, and the fact that much work had been done on these larvæ by zoologists who were apparently ignorant of the conditions necessary for their healthy existence. Each larva when it had attained the size of a pin's head required for its healthy existence at least a pint of water changed frequently. The precautions necessary for the successful rearing of these larvæ would probably lead to good results if applied to cultures of larvæ belonging to lobsters and other animals of economic importance.

The primary body-cavity, or blastocoele, was shown to contain a thick solution of proteid matter, which became thinned as development proceeded; and as this development consisted largely of processes of infolding of the wall of the spherical vesicle of which the larva at first consisted, the thinning of the solution might bring about a reduction in pressure which rendered the infolding possible.

The secondary body-cavity exhibited a division into three metameres on each side, and there was a larval brain at the extreme front apex, both of which features recalled strongly the Tornaria larva of Balanoglossus.

The development consisted of an enlargement of the middle division of the secondary body-cavity on the left side and of the floor of an ectodermic pit which had come in contact with it, from which the nerve-ring of the adult was formed. This floor became covered with a false floor, due to the union of five interradial ridges, from which the ventral surface of the adult was formed. Aristotle's lantern, the masticatory apparatus, was formed from five pockets of the most *posterior* division of the cœlom, and was homologous with the perihæmal ring of asterids.

The young sea-urchin after metamorphosis went through a stage which might be described as the asterid stage. The blood system was a remnant of the primary body-cavity adjacent to the gut and infiltrated with the products of digestion.

9. *The Relationships of the Larva to the Adult in the Starfish.*
By Dr. A. T. Masterman.

10. *On the Cause of Salmon Disease.* *By* J. Hume Patterson.[1]

The previous investigations on salmon disease have gone to prove that it is caused by the fungus *Saprolegnia ferax*. Most of the investigations, however, were carried out before or in the earlier days of bacteriology, and this perhaps accounts for the possibility of a primary bacterial infection being overlooked.

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[1] Published *in extenso* as a Parliamentary Blue Book by the Fishery Board for Scotland.

In 1885 G. Murray published a paper in the 'Journal of Botany' in which he appeared to give conclusive evidence that Saprolegnia was the true cause of the disease, by his experiments on live fish with Saprolegnia taken from diseased salmon and grown on dead flies. By rubbing the fish with Saprolegnia thus grown he was able to produce the growth of Saprolegnia on a number of the fish, which eventually died. At first sight such experiments appear to be pretty strong proof; but when we take into consideration that Murray in his experiments was not working with a pure, but a mixed growth, which might have contained numerous bacteria as well as the fungus, it cannot be said that such experiments proved Saprolegnia to be the cause of the disease.

What has always struck me as peculiar was that such a fungus as *Saprolegnia ferax*, which grows so profusely on dead tissue, should grow so readily on live tissue and cause so much damage, and I have always been inclined to think there might be some primary bacterial infection to cause the dead tissue on which the Saprolegnia developed. This view was further supported on three diseased salmon being received for examination at the sanitary chambers, for, on cultures in gelatine being made from them almost pure growths of a very rapidly liquefying bacillus were obtained.

I then resolved to thoroughly investigate the cause of the disease.

Pure cultures of the liquefying bacillus and Saprolegnia were obtained from diseased salmon. Great difficulty was experienced in obtaining pure cultures of the fungus, as the mycelium was always covered with numerous bacteria, and it was only after numerous cultures had been made that a pure growth was obtained. The fungus was grown in flasks containing liver and water, both sterile. This medium was found most suitable for obtaining spore formation.

From the results of the numerous experiments carried out with these pure cultures it may be deduced:

(1) *That Saprolegnia ferax is not the cause of salmon disease*, as twenty-seven fish of different kinds (rainbow trout, dace, river trout, sea trout, and gold-fish) inoculated with and kept in direct contact with pure spore-bearing cultures of the fungus in every case remained quite healthy, while there was a profuse growth in each case on the boiled sheep's liver with which the fish were fed, in some cases almost completely filling the jars, showing that the fish had every opportunity of becoming infected with the fungus.

(2) *That salmon disease is caused by the liquefying bacillus* (*Bacillus Salmonis pestis*), as the bacillus was found present in almost pure cultures in all the eight diseased salmon examined as well as the infected fish; while experiments showed the absence of the bacillus from ordinary dead fish. Five fish of different kinds inoculated with pure cultures of the organism all died without showing any growth of the fungus. On the other hand, six fish inoculated with pure cultures of the bacillus + Saprolegnia all died showing growths of the fungus. Again, ten fish inoculated with the fungus + other micro-organisms found in diseased salmon remained quite healthy.

Further proof was also obtained from the cut sections of the fish examined microscopically, where the bacillus was seen in large numbers invading the healthy tissue, while the fungus, when present, was only observed on the superficial necrosed parts.

The mode of infection appears to be that the bacilli gain entrance to the softer tissues of the skin by a wound on the healthy fish or by a degenerated mucus gland on the sickly fish, and passing along underneath the skin cuts it off from nutrition; the skin thus cut off becomes degenerated and forms a suitable nidus for the growth of the fungus.

(3) *Salmon disease is not contracted when the skin of the fish is in a healthy state*, as two fish not scratched in any way and placed in jars of water containing pure cultures of the organism and Saprolegnia remained alive and healthy; while on the other hand a fish placed in a jar of water containing the organism + Saprolegnia, with a layer of finely powdered sand at the bottom, in a very short time

contracted the disease and died, showing how easily the skin may be prepared for the reception and invasion of the organism.

The cold season (October to February) is more favourable to the growth of the bacillus, as it has been shown to be destroyed at a moderate temperature (37° C.) and on the other hand to grow profusely when placed for a week in a freezing mixture of ice and salt.

The experiments have also shown that fish akin to salmon are much more susceptible to the disease than others, as rainbow trout, river trout, and sea trout when attacked succumbed in from two to four days, while dace and gold-fish died in about eighteen days and thirty-five days respectively.

That dead fish, whether diseased or not, are a suitable medium for the growth of the organism and propagation of the disease has been shown by the transmission of the organism from diseased fish to healthy dead fish in the same water, and also from the dead fish to the living, and I would strongly urge that all dead fish and animal matter should, immediately it is observed, be removed from the river and burned, *not buried*, as by burying the organism is left in a condition to be again carried into the stream.

The chief characteristics of the bacillus are these:—

A short thick bacillus with rounded ends and actively motile.
Non-spore-bearing.
Grows profusely at the room temperature.
Grows profusely when exposed to 0° C. for a week.
Shows little or no growth at 37° C.
Is killed at 37° C. in about six days.
Liquefies gelatine with extreme rapidity.
Coagulates and digests milk.
Grows well in sea-water.
Forms a cloudiness in glucose agar in the neighbourhood of the growth.
Strict aërobe.
Involution forms, only observed on glucose media.
Does *not* stain by Gram's method.
Pathogenic to fish.
Non-pathogenic to frogs, mice, and guinea-pigs.

SATURDAY, SEPTEMBER 18.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Papers were read:—

1. *The Segmentation and Early Developmental Stages of the Australian Native Cat* (Dasyurus). *By* Professor G. B. Howes, *F.R.S.*

2. *Recent Intercrossing Experiments with Dogs.* *By* Professor J. C. Ewart, *F.R.S.*

3. *Flower-like Insects from the Malay Peninsula.* *By* Nelson Annandale.

4. *On Protective Resemblance in the Malay Peninsula.*
By H. C. ROBINSON.

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5. Professor E. B. POULTON, *F.R.S., exhibited:—*(1) *Lantern Illustrations of British Insects in their natural attitudes.* (2) *Three-colour Lantern Slides of Mimicry, Protective Resemblance, Seasonal Forms of Butterflies, &c., and opened a discussion on 'The Interpretation of such Phenomena by the Theory of Natural Selection.'*

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6. *Examples of Australian Fauna. By* THOMAS STEEL, *F.L.S.*

Mr. Steel exhibited and described a collection illustrative of Australian zoology. It included a series of the Australian and South African *Peripatus.* He showed an extensive series of land planarians, having especial reference to the variation in shape, coloration, and size amongst the different species.

A complete series of embryos of Dasyurus was also shown, and among the other interesting objects were the mole-marsupial *Notorocytes typhlops* and the honey ant, *Camponotus inflatus,* both from Central Australia, the ant showing the condition of distension with honey under which the abdomen becomes so inflated that the segments appear like plates attached to a balloon-like body.

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7. *Notes on a Specimen of the Pilot Whale* (Globiocephalus melas).
By Professor R. J. ANDERSON, *M.D.*

This whale, which has been examined by so many observers, is variously described as regards dentition and colour. Murie in his classic figure gives the prominent head as behind the level of the anterior part of the muzzle. An example of this creature drifted ashore at Roshill, not far from the Round Tower, Co. Galway. The cause of the isolation became apparent on examination of the carcass. An harpoon wound was seen near the tail root: this reached down to the spinal column. The animal escaped after being wounded and after a period of wandering reached the west of Ireland and Galway Bay. The animal remained warm forty-eight hours after death. The length was 20 feet 6 inches. The flippers are not so small proportionally as were those of some large specimens described. The dorsal fin is of the usual kind. The very prominent frontal convexity reaches farther forwards than the muzzle, so that the mouth is below a slight concavity overhung by a great convexity.

The colour was whitish grey or dirty white. The leading whale has been described as very dark in colour and a whole school as cream-coloured. The presence of a fin distinguishes this animal from Beluga. A thin pellicle separated soon from the rest of the epidermis, which was quite black beneath.

Teeth twenty-eight, seven on each side, above, and below. Although this number seems large and unusual, Mr. Beddard fixes the limit at forty $\frac{10-10}{10-10}$.

The peritoneum was expected to present some features of interest. The great omentum reached far back, containing the small peritoneal cavity which communicates by a foramen of Winslow with the large peritoneal cavity. The foramen of Winslow will admit the closed fist. A Globiocephalus examined by myself some years ago showed no evident foramen of Winslow. It is evident that a weighty peritoneal fold strengthened by a weighty blood-vessel or tube might promote the formation of a foramen or even to the freeing of the tube, as happens in some animals. Rathke noted the early absence of a mesentery in some fishes, even at a very early age. The origin of the small sac was shown by J. Müller to be connected with the enlargement and turning over of the stomach. It is possible that friction and the strong vascular cords may aid in producing this sac also. Professor Robinson of Chicago has suggested that fluid pressure is a powerful aid to friction in producing bursæ. With this view his evidence will induce most people to concur.

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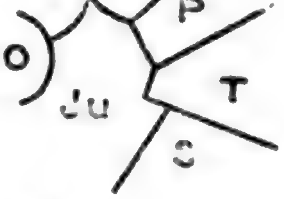
8. *The Connection of the Anterior Inferior Angle of the Parietal Bone in Primates.* *By* Professor R. J. ANDERSON, *M.D.*

The extension of the parietal bone has evidently so important a bearing on the development of the brain that its dimensions are regarded as important aids in estimating the grade of the animal. The breadth of the bone compared with the length becomes also remarkable in the higher types.

Notice the antero-posterior diameter in Strix, which is to the lateral as 9 : 10. The frontal is scarcely involved in this broadening in proportion to its breadth. The length to the breadth is 25 : 10. But this superficial increase, as in Gallus, if taken as an index of brain growth, is delusive, for the thickness of the bone is considerable. The parietal in a young ostrich is almost as thick as it is long, and gives a thickness of 12 mm. to a length of 14 mm. The length of the brain cavity is 18 mm. In fishes the discrepancies are of course further increased by the accumulation of excessive growth of the skull and the fluid which reacts, so that the skull ceases to be an index of the brain inflation. It is evident that in the highest types the occipital and frontal supplement the parietal efficiently. The interparietal itself is perhaps an occipital element (Meckel). The parietal is 4·2 cm. in Capybara compared with length of cavity of 9·5. The side connections of the parietal become of great moment in the highest groups. Sphenoidal alæ and squamosal aid the parietal to a varying degree. It is of importance of course to bear in mind the various functions allocated to sphenoidal, temporal, and even frontal before the parietal has yet joined them. So that progress of ossification is apt to be affected differently in different groups and in different members of the same group. The portions of the parietal and temporal covered by the *temporalis* have evidently a force that tends to bring these bones into unison, but in its early associations the squamous is materially different. The alæ of the sphenoid are even less concerned, and the diversion of ossific material appears to take place with greater facility, and in the lines of suture of the parietal remain long incomplete, especially at the angles. It is, however, remarkable that the lines of suture are not more variable in position than they are. A slight modification in position may perhaps not be regarded as of great significance. But any variation that leads to an alteration in the articulation of the anterior inferior angles of the parietals must be of importance. Taking a few examples:—

The Kangaroo, Dugong, Leo, Ursus polaris, Hyæna, Canis, Cystophora, Felis catus, Galago, Lemur, Mycetes, Cebus, Pithecia, Hapale, Gorilla (?), Orang, Man, Macacus rhesus (some), Semnopithecus entellus (some), Hylobates hainanus, all have a parieto-sphenoidal articulation. The articulation varies in length; in a Mycetes it was $\frac{3}{4}$ inch.



The following, viz., Orang (?), Hylobates mülleri, Homo (occasional), Semnopithecus obscurus and entellus (some), Macacus cynomolgus (some), Macacus rhesus (some), have not parieto-sphenoidal sutures.

The following, Loris gracilis, Semnopithecus leucoprymnus, Gorilla (?), have a parieto-sphenoidal suture which is not well marked and is sometimes reduced to a point.

The temporal touches the *jugal* in Hylobates mülleri, and thus shuts off the parietal, which also touches the jugals from the *sphenoid.*

The *same* arrangement *almost* takes place in Tarsius spectrum.

The Cynomolgus, mentioned above as not having a parieto-sphenoidal suture, has two small Wormian bones in the naso-frontal fissure. In the Homo above alluded to the temporo-frontal suture is 20 mm. long, and the sphenoido-frontal 11 mm. There are Wormian bones in the lambdoidal suture.

There are Wormian bones in the naso-frontal suture of the leucoprymnus referred to above, where the premaxillary bones almost reach the frontals.

The parietal and sphenoid touch the jugal in Hapale jacchus and some other American monkeys.

This arrangement arises from the forward extension of the parietal, excluding the frontal from the sphenoid, and then the forward extension of the temporal may exclude both frontal and parietal from the sphenoid.

9. *Notes on the Habits of the Onuphididæ (Polychæta) and on the Internal Structures with which they Fortify their Homes. By* ARNOLD T. WATSON, *F.L.S.*

The Onuphididæ are closely allied to the Eunicidæ, from which they are distinguished, amongst other things, by their always dwelling in deep water, whilst the Eunicidæ are often found between tide-marks.

Observation of the British forms, *Hyalinœcia tubicola* and *Onuphis conchilega*, while living in captivity, shows them to be errant worms, moving from place to place and carrying their tubes with them. These tubes are open at both ends, but the animal protects itself from the attack of enemies by constructing within, at either end, membranous valves, on the principle of the valves in a vein, the open ends of the pockets of which are directed outwards, so that by inrush of the sea-water the valves are automatically closed on retreat of the inmate.

In the quill-like, chitinous, transparent tube of *Hyalinœcia* the valves existing, or which have existed, are indicated by the ornamental V-shaped or zig-zag markings.

The valves of *Onuphis conchilega* are much more delicate in structure, but nevertheless are distinctly demonstrable in the internal membranous tube, on removing with a weak acid the shelly covering which forms the scabbard-like sheath.

Very perfect valves of the kind described were also found in the tube of *Nothria pycnobranchiata*, obtained by the 'Challenger' Expedition from a depth of 2,225 fathoms.

The habits of animals living at so great a depth can, of course, only be conjectured, but there is reason to think that, like the British species, these members of the family may be errant worms.

The paper was illustrated with lantern slides, and will be published in full by the Liverpool Biological Society.

10. *On an Acœlous Turbellarian inhabiting the common Heart Urchin. By* R. T. LEIPER.

The turbellarian described in this paper was found by me in the accessory canal of about 8 per cent. of the specimens of *Echinocardium cordatum* occurring at Millport, N.B., several examples being usually present in the same host.

It is whitish and moderately translucent in appearance, leaf-like in shape, obovate when contracted, lanceolate when extended, the blunt end being anterior.

When fully extended it measures in length 2·5 mm.; in breadth, transversely, 0·6 mm.; dorsiventrally, 0·2 mm.

The microscopical structure is described in some detail, an interesting and characteristic feature being the presence of a large digestive vacuole occupying the anterior middle fourth of the body, and lying above but not in immediate continuity with the mouth.

No vagina or spermotheca is present, the ova being extruded by the rupture of the cuticle at a short distance in front of the penis owing to an ever-increasing growth pressure.

In some points this turbellarian resembles *Böhmigia*; it possesses, however, no female accessoria; a similar absence obtains in the genus *Haplodiscus*, from which also it differs in the following not unimportant details:—

(1) Shape.
(2) Parasitic habitat.
(3) Mouth situated in the anterior fourth.
(4) Paired testes in the lateral parts of the body.
(5) No defined vasa deferentia.
(6) Penis with chitinous knob-like armature.
(7) Presence of a large dorsal vacuole.

Attention is drawn to the present classification of the Acœla. It is suggested that the family *Proporidæ*, comprising all Acœla with one genital opening, be subdivided into two sub-families.

(1) *Proporinæ*, including the genera (a) *Proporus*, (b) *Monoporus*, (c) *Böhmigia*, *i.e.*, those Acœla with a common genital atrium.

(2) *Avagininæ*, consisting of (*a*) *Haplodiscus* and (*b*) the genus presently described, these having male accessoria only.

TUESDAY, SEPTEMBER 16.

The following Papers were read:—

1. *Some Remarks on the Atlantis Problem.* *By* R. F. SCHARFF, *Ph.D.*

Since the dawn of early history the question of the existence of a continent beyond the 'pillars of Hercules' has occupied the mind of man. Our very earliest records of this mythical land were derived from a narrative which has been handed down to us by Plato. According to it, Solon is said to have visited Sais in Egypt, and there to have heard from priests of the ancient 'Empire of Atlantis' and of its overthrow by a convulsion of Nature. This Atlantis was then spoken of as a vast land lying beyond what we now call the Straits of Gibraltar, and it is supposed to have been inhabited by a mighty race of people. Plato's story has called forth quite a flood of literature, not only in ancient times; even within the last score of years many pamphlets and books have been published dealing with this attractive problem. Some authors have sought to discredit the veracity of Plato's assertions, while several, and among them Humboldt and Sir Daniel Wilson, were of opinion that the tale rests on some historic basis. Others again have utilised the original story and connected it with their own ideas of a land-bridge stretching right across the Atlantic from Europe to America.

The Atlantis problem, however, was only raised to scientific importance when modern research revealed the fact that the living as well as the extinct flora and fauna of Europe have quite a number of types in common with North America. Unger was the first to put forward the view, from a purely scientific reasoning, that the Atlantic Islands, that is to say, the Azores, Madeira, and Canary Islands, formed part of a land-connection which stretched right across the Atlantic and still preserved some of the plants which invaded our Continent from the New World. Heer hailed this hypothesis with delight, while Andrew Murray adopted it in a somewhat modified form. Edward Forbes also occupied his fertile mind with the problem, but could not convince himself that the vast land which had evidently occupied a portion of the Atlantic had any connection with America. Wollaston, too, who had a most intimate knowledge of the Atlantic Islands, strongly supported the view that their fauna reached them across dry land.

Imbued, however, with the idea of the permanence of the great ocean basins, Wallace vigorously attacked one and all of these theories, and contended that there was not only no connection between Europe and America across the Atlantic, but that the fauna of the Atlantic Islands was derived from the adjoining continents of Europe and Africa by winds and marine currents. The weight of the arguments brought forward by Wallace silenced all critics for a time, and the influence of his views is traceable in most of the more recent writings on the subject. But, since some leading geologists have expressed themselves against the theory of the permanence of the great ocean basins, the older views of a possible land-connection between Europe and the Atlantic Islands, and also between Europe and America, are again discussed. I have therefore collected together a number of facts regarding the distribution of animals which had not hitherto been utilised, in order to make a renewed attempt from a zoological point of view to solve the Atlantis problem.

The results of my investigations tend to show that Madeira and the Azores are the remains of an ancient tertiary area of land which was joined to Europe, and that it probably became disconnected in Miocene times. Since then this land once more became united with our continent, and may not have been finally severed until the Pleistocene period. As regards the question of a land-bridge across the Atlantic, many reasons can be given in favour of such a theory. It must, however, have occupied a position farther south than the land just alluded to. Uniting North Africa with Brazil and Guiana in early tertiary times it probably subsided during the Miocene period, leaving only a few isolated peaks as islands in the midst of the vast ocean which has since replaced it.

2. *Diagram of the Skull of* Mastodon angustidens.

By Dr. C. W. ANDREWS, *B.A., F.G.S., F.Z.S.*

The especial interest of the diagram exhibited lies in the fact that it corrects those figures of *M. angustidens* previously published, notably that by Professor Gaudry, which shows the tusks curving upwards like those of an ordinary elephant. The downward direction of the tusks in this early proboscidean is particularly interesting as being a primitive character derived from the early ancestral form *Mœritherium*, lately discovered by the author in Egypt. In this it is clear that the tusks are merely an enlarged pair of second incisors, and there seems no reason to doubt that in *Palæomastodon*, *Mastodon*, and the later elephants the upper tusks are homologous with those teeth.

Another remarkable character of the early mastodons is the immensely elongated mandibular symphysis, which is prolonged far beyond the upper jaw, and bears a pair of procumbent incisors which terminate in a chisel-like worn surface. Considering that they project far in front of the upper jaw, and lie between the widely divergent upper tusks, it is difficult to see what they worked against unless it was a hard surface on the ventral face of the proboscis.

3. *The Breaking-up of Coral Rock by Organisms in the Tropics.*[1]

By J. STANLEY GARDINER, *M.A.*

The problem is mainly of interest from the bearing that it has on the formation of the lagoons of atolls out of flat surface reefs. There are two classes of animals—those which bore into coral or coral rock and break it down into small fragments and stones, and the sand-feeders, which further grind these up into fine sand and mud. Both these series of forms are extremely scarce on the outer slopes of atoll reefs, while they are the most abundant animals found within the lagoons of our atolls. First the boring alga, *Achyla*, and the sponge, *Cliona*, penetrate the living corals, extending into every septum and spine. They weaken the coral, and so riddle it that it is then easy for the boring Polychæta, such as *Polydora* and *Eunice*, to enter. Following these come various Sipunculid worms, the bivalve *Lithodomus* and the cirriped *Lithotrya*. A wave breaks off the coral mass, leaving a bare surface, which more of the boring animals at once take advantage of. The fallen coral mass is broken down into smaller and smaller fragments by the boring animals. Then the sand-feeders come into action and grind up the coral fragments into sand. Chief among these may be mentioned the sea-slugs, *Holothuria atra* and *Stichopus chloronotus*, which appear to retain within their guts the coarser fragments of the sand, while the finer particles are swept out along their ciliated grooves. Other forms are *Sipunculus*, numerous sea urchins, and *Ptychodera*, the mound-like casts of the latter of which form a most conspicuous feature of the landscape at low spring tides. Much of the finer material must pass into suspension in the water, and be swept out of the atoll by the tidal and oceanic currents, while the smaller the sand grains the greater the area they present for solution. It will thus be clear what an important bearing the study of the boring and sand-feeding animals has on the formation of the lagoons of atolls.

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[1] A full account of the action of boring and sand-feeding organisms will be found in *The Fauna and Geography of the Maldive and Laccadive Archipelagoes*, Camb. Univ. Press, vol. i., pt. 3, pp. 333–341 (October 1902).

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4. *The Early Development of Muscles and Motor Nerves in Lepidosiren.*

By J. GRAHAM KERR.

Development of the Myotomes.—The conversion of the inner wall of the myotome into a muscle-segment takes place in *Lepidosiren* in a manner closely resembling what happens in *Amphioxus* and *Petromyzon*. I have been able to make out the details of the process fairly completely.

In early stages of development the inner wall of the myotome consists of a simple layer of very large epithelial cells, columnar in transverse sections, but really forming rectangular parallelepipeds somewhat compressed in a dorso-ventral direction and sloping inwards and downwards. The muscle-fibres appear as fine, highly refracting, rod-like differentiations of the protoplasm, running longitudinally from end to end of the muscle-cell, and conspicuous by their staining deeply with Heidenhain's iron hæmatoxylin. These fibres become visible about stage 26, and they are at first as a rule confined to the dorsal and ventral faces of the cells, forming thus in each cell two layers, a dorsal and a ventral. Fibres also develop between the outer ends of these layers, so that now the fibres in each cell show a ⊃-shaped arrangement in transverse sections.

As development proceeds other fibres arise in the protoplasm lying within the limbs of the ⊃-shaped arrangement, until the cell body is to a great extent filled with the fibres.

The mass of contractile fibres does not extend to the outer end of the cell. This is occupied by clear protoplasm containing one or more large vacuoles. Whether these contained glycogen in the fresh condition I cannot say.

Up to stage 31 the outer wall of the myotome remains a simple layer of cubical cells. About this period, however, active multiplication of the cells takes place, and in transverse sections several layers of nuclei are seen. In horizontal sections, also, numerous nuclei are seen scattered through the whole distance between anterior and posterior boundary of the myotome. No cell limits are visible, but we may take it possibly that the cell territory presided over by each nucleus extends the whole length of the myotome, for now (stage 31 +) striated muscular fibrils begin to appear in the protoplasm between the nuclei, stretching quite continuously the whole length of the myotome. In somewhat shrunken transverse sections each bundle of fibrils is seen to be contained in a sheath of protoplasm containing a nucleus at one side, the whole forming a somewhat cylindrical 'cell' stretching from the one myoseptum to the other. In life probably these elements are prismatic and fit closely together, the cylindrical form being due to shrinkage. The outer wall of the myotome increases much in thickness, becoming eventually considerably thicker than the inner. About stage 35 there can be distinguished in the myomere two layers of muscle—derived from the two walls of the myotome, the inner and the outer, and differing decidedly in their characters—the muscle-cells of the outer layer being long thin cylinders, as has been described; those of the inner being, on the other hand, flattened parallelepipeds. The bundles of fibrils of the outer layer are also separated by more abundant protoplasm, with more numerous nuclei. A further difference, probably due to the active metabolism involved in the multiplication of the nuclei and the growth of the layer in thickness, is that the outer layer is practically free from yolk-granules, while the inner is still richly provided with them.

About the stage just mentioned, however, the blocks of fibrils of the inner series become irregular in outline, as seen in transverse section, they are constricted in places, and finally separate completely into more or less isodiametric masses resembling those of the outer series. By about stage 36 + the whole of the muscle-bundles in the myomere have assumed the same character, *i.e.*, the character at first possessed by only the outer series.

The main features of myotome development recorded above are of especial interest in regard to two points: first, in the close resemblance that the early stages bear to the equivalent phenomena in *Amphioxus* and *Petromyzon*; secondly, in the striking way in which *Lepidosiren* agrees with Balfour's view in regard to Selachians, that the outer wall of the myotome takes part in muscle formation, a view given up almost entirely by recent workers.

The Neuromyoepithelial Cell.—There remains to be mentioned a phase of great morphological interest, which occurs transiently in the muscle-cells of the inner wall of the myotome. It has been recognised for *Amphioxus* and *Petromyzon* (Rabl, Hertwig, Maurer) that in an early stage of development these muscle-cells are definite myoepithelial cells.

This is similarly perfectly clear in *Lepidosiren*; but here I have found an additional important detail—namely, that at least some of the myoepithelial cells are continued at their inner ends into tail-like processes continuous with the motor-nerve trunk. Each cell is, in fact, neuroepithelial as well as myoepithelial in character.

The Motor Nerves.—The method of development of the peripheral nerve-trunks is one of the most disputed questions in vertebrate morphology. Of the various views which have been held on this subject the one which is predominant at the present day is that associated with the name of His—namely, that the peripheral nerve-fibre is an outgrowth from the central nerve-cell, that it grows outward from this origin, and eventually becomes joined up to its end-organ. Hensen long ago suggested that, on the other hand, the end-organ and the nerve-centre are joined up from the beginning. This view, though still held on mainly theoretical grounds by several embryologists, has lacked the support of definite observation. *Lepidosiren* happily during its development shows facts which may almost be regarded as demonstrating the truth of Hensen's view in its main principles as regards the motor nerves. In tracing back the motor trunks of the spinal nerves I reached a stage in which the faintly fibrillated trunk was ensheathed in a nucleated mass of protoplasm of mesenchymatous origin. It seemed as if the nerve-trunk were becoming differentiated out of the strand of mesenchyme—that it developed exactly after the fashion described by Sedgwick for Selachians. Pushing back my investigation to earlier and earlier stages, however, I was astonished to find the nerve-trunk rudiment well developed, while there was as yet no trace of its ensheathment of mesenchyme. Eventually a stage was reached at which the myotome and the neural tube were still in close contact, and where, of course, it was practically impossible to demonstrate the existence or non-existence of connecting bridges between the two. Fortunately I had when in South America been able to excise numerous embryos of this stage from the egg during life, to spread them out in one plane under normal salt-solution, and in this position to subject them to the action of the fixing agents. On examining transverse sections of such embryos I found that the myotome had become slightly drawn away from the neural tube, and examination of series of sections brought out the fact that the rudiments of the motor trunks already connected myotome and central nervous system at this period of development—before they had begun to recede from one another with the interposition of mesenchyme. *Lepidosiren* thus affords a definite anatomical basis for the view that the nervous bridge between nerve-centre and end-organ exists from the beginning, and that the growth of the nerve is a drawing out of this bridge as the end-organ is pushed away by the development of underlying mesenchyme.

I have so far been able only in the case of the *motor* trunks to trace them back to this stage; in the case of some of the sensory nerves of the head I have got back to the stage in which the nerve-trunk appears to be developing in its sheath of protoplasm, and I have no doubt that in time research will show that this stage is preceded by exactly the same stages as is the case with the motor nerves.

The motor trunk in the earliest stage which I have seen has the appearance of a simple protoplasmic bridge. It is very thin, and there is no obvious appearance of fibrillation. What happens to it within the wall of the neural tube observation does not show. In well-preserved specimens the wall of the neural tube shows no structure except nuclei closely packed in granular protoplasm, in which cell-boundaries can scarcely be distinguished. At its outer end the nerve-trunk splits up and is continued into the substance of the muscle-cells.

5. *The Development of* Xenopus (Dactylethra). *By* E. J. BLES, *B.Sc.*

6. *Experiments on the Axolotl: Adaptations to Life in an Alkaline Medium.* *By* E. J. BLES, *B.Sc.*

7. *On the Insect Fauna of some Irish Caves.*
By GEORGE H. CARPENTER, *B.Sc.*

Only a few of the numerous caves in the limestone districts of Ireland have as yet been searched carefully for a living fauna, but these have already yielded results of considerable interest. The present communication deals with the Springtails (*Collembola*) that have been discovered in the Mitchelstown Cave, near Cahir, Co. Tipperary, and in the Dunmore Cave, near Kilkenny.

An exploration of the former cave in 1857 by Haliday and Wright resulted in the discovery of many specimens of a white blind springtail that was doubtfully identified with the Carniolan cave species, *Lipura stilicidii*, Schiödte. This insect is now known to be identical with the widespread *L. inermis*, Tullberg, a species that inhabits both caves and the upper world in many parts of Europe and North America. All the species of this genus, whether in caves or above ground, are destitute of eyes.

All the Irish caves seem to be inhabited by *Tomocerus tridentiferus*, Tullberg, and in this species pigment and eyes appear to be always well developed.

Heteromurus margaritatus, Wankel (= *Templetonia cavernicola*, Carpenter), a pale blind species, inhabits both Mitchelstown and Dunmore caves. This form is widespread in the Continental caves, and has not yet been discovered above ground. But it is closely allied to *H. nitidus* (Templeton), that occurs in mould.

Pseudosinella cavernarum (Moniez) abounds in the Mitchelstown Cave. This is a blind white species that was first discovered in a deep cavern in the South of France. It has since been found in quarry-tunnels and in ants' nests in Scotland, and under stones on fields in Norway. Its congener, *P. alba* (Packard)—hitherto unrecognised in the British Isles, occurs in Dunmore Cave.

This species, though white, has well-developed paired pigment-spots on the head, each with two ocelli. It is known to inhabit North America, Norway, and South Germany.

Smynthurus coecus, Tullberg, is a very interesting blind species from the Mitchelstown Cave. It has been found also in an old quarry-tunnel near Edinburgh, and in mould in Northern Europe.

It seems that the only Irish cave-insect that can at all probably be considered blind and degenerate as the result of life in the darkness is *Heteromurus margaritatus*, which is, perhaps, the modified descendant of *H. nitidus*. If so, the form must have been independently developed in the different caves it inhabits.

Such insects as *Smynthurus coecus* and *Pseudosinella cavernarum* are evidently very ancient species that have become almost exterminated in the upper world, but are able to hold their ground in the caves. It has lately been suggested by Verhoeff that cave-faunas, as a whole, are survivals, rather than special modifications. Certainly the Irish cave-fauna, so far as it has yet been investigated, affords support to this view. But the richer fauna of the Continental caves must probably be, in part at least, due to modification. It would appear that the origin of cave-faunas is a more complex question than is usually imagined.

8. *On the Significance of the Embryonic Cell. By* Professor C. S. Minot.

9. *The Bird-fauna of Ireland as affected by its Geography.*

By R. J. Ussher.

The position of Ireland being remote from other countries, its maritime counties chiefly mountainous, its interior containing many lakes, and three-fourths of its area being under grass or moor, coupled with the smallness of its manufacturing districts and the absence of persecution of birds except as game, the result is that species breed numerously and extensively here as compared with England; for example, Stonechat, Dipper, Golden-crested Wren, Grey Wagtail, Goldfinch, Siskin, Twite, Lesser Redpoll, Corn Bunting, Chough, Magpie, Hooded Crow, Peregrine Falcon, Red-breasted Merganser, Rock Dove, Golden Plover, Woodcock, Common Snipe, Dunlin, Curlew, Arctic Tern, Little Tern, Common Gull, Great Black-backed Gull, Black Guillemot, Storm Petrel, and Manx Shearwater.

Among the winter visitors, too, are many wildfowl, Swans, Geese, Ducks of both groups, which resort to the estuaries of the north and west, to desolate moors, and to lakes and islands in prodigious numbers. *Limicolæ*, as the Turnstone, Purple Sandpiper, Sanderling, Greenshank, and Bar-tailed Godwit, and the Great Northern Diver linger on into May, or even through the summer, on the north and west coasts.

Other species which breed in Britain are absent from or limited in Ireland. Among the absent species are the Nightingale, Dartford Warbler, Reed Warbler, Marsh Warbler, Bearded Titmouse, Crested Titmouse, Nuthatch, Tree Pipit, Cirl Bunting, Tawny Owl, Capercaillie, Black Grouse, Ptarmigan, Red-legged Partridge.

The following do not breed in Ireland, being rare occasional visitants or scarce migrants:—Lesser Whitethroat, Red-backed Shrike, Pied Flycatcher, Wryneck, Woodpecks (all the British species), Common Buzzard, Hobby, Eider Duck, Turtle Dove, Stone Curlew, Ruff, Great Skua, Richardson's Skua, Fulmar.

Eight birds have a restricted breeding range in Ireland, viz., Whinchat, Redstart, Garden Warbler, Wood Wren, Yellow Wagtail, Tree Sparrow, Jay, Stock Dove.

Among the occasional visitants the British list contains a large number that have never been recorded from Ireland.

The result is that the Irish list of birds contains much fewer species than those of Great Britain.

The Common Buzzard, the Bittern, and the Capercaillie have been exterminated y man; but the absence of other birds seems to be due to the fact that they have ever established a footing in Ireland at all.

Among the birds of Ireland there are two groups specially characteristic of heir resorts as (1) certain Ducks, Waders, Gulls, and Grebes which breed on the akes and bogs; and (2) the rock-breeding birds of the coast, including the Chough, Raven, Eagles (rare), Peregrine, Cormorants, Rock Dove, Oyster-catcher, Gulls, Auks, and Petrels.

The chief sea-bird colonies are on the Saltee Islands, Lambay, Rathlin, Horn Head, Tor More, North Mayo Cliffs, the Bills of Achill (where some fifty pairs of Great Black-backed Gulls nest), the Cliffs of Moher, Loop Head, the Blasket Islands, the Skelligs, and the Bull and Cow Rocks.

Arctic Terns have their largest colony on Roaninish Island, co. Donegal.

There is considerable similarity between the bird fauna of the Scottish and Irish coasts; while the abundance of the Hooded Crow and the frequency of the Siskin and Twite in both countries are other points of resemblance.

The most southern breeding-haunts in Europe of the Common Gull and of the Red-breasted Merganser are in Co. Kerry.

The northern affinities of the Irish avi-fauna are limited, for neither the Eider Duck nor several North British waders, the Skua nor the Fulmar, breed in Ireland; but the following are among the species that have often visited Ireland from the high North: Mealy Redpoll, Greenland Redpoll, Snow Bunting (commonly), Snowy Owl, Rough-legged Buzzard, Greenland Falcon, Snow Goose, King Duck, Sabine's Gull, Glaucous Gull, Iceland Gull, Pomatorhine Skua, Buffon's Skua, Little Auk.

The following North American species have been taken in Ireland, the figures representing the number of their occurrences:—American Bittern (13), Surf Scoter (6), Hooded Merganser (4 or 5), Lesser Golden Plover (1), Pectoral Sandpiper (3), Bonaparte's Sandpiper (1), Bartram's Sandpiper (2), Buff-breasted Sandpiper (2), Spotted Sandpiper (1), Red-breasted Snipe (2), Eskimo Curlew (1), Bonaparte's Gull (1).

Besides these, seven American land birds have occurred, but on these doubt has been thrown, as having possibly had assisted passages. Six Antarctic and oceanic species have been recorded—Yellow-billed Sheathbill (possibly escaped), Noddy Tern, Wilson's Petrel, Little Dusky Shearwater, Great Shearwater, Sooty Shearwater. The two latter occur numerously in some seasons, late in summer, along the coasts of Cork and Kerry.

Migration Routes.

Immigrant birds arrive on the coasts of Ireland mainly in two directions.

(1) The summer migrants and most of the *passerine* winter immigrants land on the south and east shores. Many visitants on arriving there seem to travel onwards along the coasts of Waterford, Cork, and Kerry, and this accounts for the large number of rare birds that have been taken in the estuarine valleys of Co. Cork. Vast numbers of small birds belonging to common species accounted residents arrive in autumn on the south-eastern shores to pass the winter in the mild climate of the south. There is a second immigration of these in spring.[1]

(2) Those winter visitants that come from the far north arrive chiefly on the coast of Donegal, and pass down the west coast of Ireland, while some pass to the east coast by the North Channel. The White Wagtail in spring passes up the west coast.

Increase of Certain Species.

The following have settled in the country as breeding species and are increasing:—Magpie (since the seventeenth century), Missel Thrush (100 years ago), Woodcock (since 1833), Starling, Tree Sparrow, Shoveler, Crossbill, Redstart, Tufted Duck, Stock Dove. Many woodland birds too have increased.

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[1] *Migration of Birds* (Barrington), published by Porter and by Ponsonby, 1900.

Decrease of Species.

The Crane abounded in the twelfth century, the Capercaillie until the eighteenth century, the Bittern bred in the nineteenth century, the Common Buzzard until about 1883, the Red-throated Diver until about 1896, while the Woodlark, Raven, Marsh and Hen Harriers, Golden and White-tailed Eagles, Quail, and Roseate Tern are approaching extinction.

The Great Auk appears to have been at one time not uncommon on several parts of the Irish coast, for Mr. Knowles has discovered its remains in Co. Antrim. I have found the bones of six or eight individuals on the Waterford coast, and other bones have been obtained in 1902 in Co. Clare. In each case the remains of Great Auk were found in kitchen middens, with other bones used for food by the ancient inhabitants, by whom this bird was evidently captured.

10. *On the Structure of the Scales in the Cod.*

By H. W. MARETT TIMS, *B.A., M.D.*

The development of scales in various fishes has been described by several writers, notably by Hertwig and Klaatsch, the latter dealing also with many of the morphological aspects. There is, however, an almost entire absence of detailed observations as to the structure and pattern of the fully formed scales, and some of the transitional stages in the growth of the scale appear to have escaped observation.

Through the kindness of Professor Macintosh, F.R.S., I have been enabled to work at this subject during the past few weeks in the Gatti Marine Laboratory at St. Andrews. I have confined my observations in the first instance to the scales of the Gadidæ, the species examined being *G. virens*, *G. morrhuæ*, *G. pollarchus*, and *G. leucus*. The younger stages were taken from Professor Macintosh's rich stores, while the older were mostly from material freshly caught.

The formed scale is a compound structure consisting of a fibrous stratum upon the upper surface of which are situated numerous 'scalelets' arranged in lines radiating from a more or less homogeneous centrum. The form of these scalelets varies somewhat in the different species, and to a certain extent in the same species at different stages. It is the presence of these structures that gives the 'sculptured' or 'ringed' appearance to the scales, but these terms, though frequently applied, are misleading.

The fibrous stratum is readily exposed by treating the scale with a dilute acid, when the scalelets are to a great extent dissolved off, or their remains easily removed by scraping. The fibres are arranged in definite layers: (i.) a superficial in which the bundles are concentric; (ii.) a deep layer in which the individual bundles interlace with one another at right angles, each set running diagonally to the long axis of the scale. A third layer, the fibres of which form an irregular network, is possibly present, but it is much more difficult to demonstrate. This fibrous stratum stains readily with any of the ordinary reagents.

The scalelets, placed upon the upper surface of the fibrous stratum, are themselves covered with a delicate epidermis, which is likewise easily stained. They consist of flattened, imbricated, calcareous plates. If the epidermis be gently removed and the whole scale be placed for a few minutes in borax-carmine, the scalelets become barely tinged with the stain, more particularly in the younger stages. If, however, the latter be previously treated with an acid, they stain rather more freely. This leads to the inference that in the earlier condition they are more thoroughly calcified, or rather, perhaps, that in the later stages they contain a larger amount of organic material, and thus stain somewhat more readily.

Between the radiating lines of scalelets the deeply stained fibrous stratum is seen, resembling the spokes of a wheel. In an early stage, before the scalelets become imbricated, the fibres may also be noticed as transverse bands passing between the individual plates of a row.

On examining a section of an undecalcified scale the scalelets are seen to be for the most part implanted in sockets on the upper surface of the fibrous stratum with a varying inclination. Those at the centrum appear to have fused, forming a horizontal plate, while at the periphery of the scale they are almost perpendicular. In a section through the skin of a green cod about 4 cm. long, the individual scalelets are quite isolated. Each consists of a basal plate, from the upper surface of which projects a minute spine, thus resembling a small placoid scale. Such a condition is only evident in material from which acid has been rigidly excluded. This condition does not appear to have been previously noted; the figures given by Klaatsch and others being similar to those which I obtained from material which had been passed through acid alcohol, and which do not show the true nature of the scale.

WEDNESDAY, SEPTEMBER 17.

Discussion upon Mimicry and Natural Selection.
Opened by Professor E. B. POULTON, *F.R.S.*

The following Paper was read :—

Some Remarks on Early Development of the Head-kidney in Polygordius and Eupomatus. *By* C. SHEARER.

SECTION E.—GEOGRAPHY.

PRESIDENT OF THE SECTION—Colonel Sir T. H. HOLDICH, C.B., K.C.I.E., F.R.G.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

The Progress of Geographical Knowledge.

WITH so large a field as that which is embraced by geography before us, I feel a little doubtful which way to turn in order to gather into one short space both the scattered records of recent geographical history and to present to you at the same time illustrations of some fixed principle which in the course of the development of our geographical knowledge must govern the progress of it. Last year you heard from Dr. Mill a most excellent summary of the present phase of that development in this country. You heard not only of great activity in the wide world of the unexplored and unknown, but of new efforts to train up a fresh generation of explorers; of new schools springing up amongst us; fresh evidence of the faith that is in us that geographical knowledge points the road to commercial success; happy intimations of the existence of a yet higher faith—the faith which believes that scientific knowledge of the world's physiology is worth the getting for its own sake, whether it paves the way to golden success or not. And now, whilst recalling the chief geographical events of the year that has passed; whilst counting the landmarks on the road to a higher geographical education, I would also claim your attention for a brief space to a few technical problems which beset the business aspect of future procedure, and which so long as we make it our boast that we belong to the biggest empire in the world ought most certainly to attract our earnest attention.

The unknown world is growing daily smaller. It is, indeed, narrowing its area with a rapidity which is absolutely regrettable. If you think of those delightful days when the men who went 'down to the sea in ships' brought gold and ivory to the steps of Solomon's Temple, believing that beyond their nautical ken all the rest of the world was but flat emptiness; or even centuries later when Marco Polo's truthful tales of Asia were discredited as wild fables; or again in almost modern times when Vasco da Gama bent his knees in pious prayer ere starting on the buccaneering venture which was to change the destinies of the East, you will find it almost impossible to look at the well-turned-out maps of to-day, wondering where next it may be possible to strike a new feature or unfold a new vista to geographical enterprise, without something like a sigh. But it is with the world as we find it mapped to-day that we have now to do, searching out the position of such blank spaces as still exist and considering the best means of dealing with the vast area of its half-exploited surface so as to obtain the best results for the time and labour spent on completing our knowledge of it.

Antarctic Prospects.

To the Polar regions we naturally turn first, for they form the special domain of modern initial exploration. We are very far yet from having elucidated the great geographical problems of sea and land distribution which lie hidden under the depths of palæocrystal ice. We only know indeed from inference that at one end of the world there exists an unmapped sea, and at the other an unmapped continent, round the edges of which we are even now feeling our way. When the 'Discovery' left Port Lyttelton, New Zealand, on December 24 last for the South Polar regions, this was the quest which, in the modest language of her originator, Sir Clements Markham, lay before her: 'To determine as far as possible the nature and extent of the South Polar lands' and to 'conduct a magnetic survey.' If we look at the unexplored area of these South Polar lands as a whole and examine the plan of international geographical campaign which has now been directed against them, we shall find, I think, that the present enterprise is by far the most complete and systematic, as it is the most scientific, that has yet been undertaken in the Far South. It is impossible but that great results should be attaned from so complete an investment of the unknown continent.

With the 'Discovery's' investigations, which will be directed to Victoria Land—the land of the historic volcanoes Erebus and Terror—from the side of Tasmania and New Zealand, will be associated at least three other expeditions, all aiming at a final solution of the South Pole problem. From South America Otto Nordenskiöld's expedition has taken the shortest sea route past the South Shetlands to Graham's Land, and has already passed a winter amidst the ice. From South America, again, the Scottish expedition under Bruce will work its way past the Sandwich Islands, skirting the Antarctic Circle, some fifty degrees to the east of Nordenskiöld, almost on the Greenwich meridian, and as nearly opposite as possible to the 'Discovery's' attack from the other side of the Pole; whilst between the two will be the German expedition of the 'Gauss,' pushing southward about the meridian of 90° E., a worthy rival in scientific equipment to our own ship the 'Discovery.' And there is no branch of scientific inquiry which will be advanced by this international attack on the great unknown southern land of more interest than that which pertains to the history of the world's geography. Independently of securing a firmer outline to the vague definition of southern land areas of the present day, it is there that we hope to find evidences of another distribution of those areas in primeval times. Shall we be able to trace the Patagonian formations, those recent basaltic lavas which overlie trees, beyond that point in Graham's Land where we know that they occur again, to the Australian side of the Southern Pole? Shall we find that Erebus and Terror are but the natural extension of that magnificent array of volcanic cones which overlook the Pacific from the Patagonian Andes? Will the Miolania, the great turtle of Patagonia—not unknown in Australia—complete with his bones another link in that chain of many evidences that Patagonia and Australia once met across the extreme south? You may say this is not geography. I hardly know whether in these days it is still necessary to plead that between geography and natural sciences, whether of geology, biology, or anthropology, the connection is so intimate that in the actual field of research it is impossible to disconnect them. Modern geography is but a development, and whilst the process of its evolution is perhaps to be found in strictly geological fields, it has so modified and influenced the problems of life and the distribution of it throughout the world that a collector of facts like myself finds it convenient to accept, for the mere sake of simplicity, the science of geography as the best basis for divergent inquiries into many other scientific fields, which can be differentiated at leisure by the natural philosopher.

Necessity for Study of Geographical History.

But whilst we are justified in expecting much from this great international movement we must still moderate our expectations. We must admit that in the field of purely naval exploration we have not the same developments in mechanical and instrumental accessories which place within our reach the possibility of conducting land expeditions on far more scientific and exact methods than were possible to our grandfathers. Wireless telegraphy, for instance, will not yet enable a ship fast bound in Arctic ice to determine her longitude, and the restless ocean still precludes the use of many of the more finely graduated instruments which are essential to the exact measurements pertaining to triangulation. Methods and instruments, indeed, will not differ materially from those adopted by Franklin or by Ross more than half a century ago. Better instruments of their class no doubt are within reach, owing to the extraordinary accuracy of modern production; but better hands to hold them it would be impossible to find. We are often so pleased with ourselves in these days that we are apt to forget what has been done by our geographical forerunners in the same field as ourselves. I have but lately returned from a journey full of geographical interest which has carried me over some of the tracks left many years ago by a British scientific expedition to the South Seas, which will be ever associated in the memory of all geographers with the names of Charles Darwin, and H.M.S. 'Beagle.' With the wider scope for gathering information which is afforded in these days by the growth of civilisation and the shooting out of its long tendrils into the waste places of Patagonia, it has been possible to verify some of the suggestions as to the structure and geographical configuration of that southern continent which were offered by the observations of Darwin, and to examine here and there, in some detail, the results of recent local surveys in testing the accuracy of the coast outline and of the coast soundings established by the 'Beagle.' Of the former I can only say that they seem to me prophetic; of the latter, so little change has taken place in South American coast configuration during the last fifty years that practically the charts of the 'Beagle' are the charts of the Chilian and Argentine Admiralties of to-day, with hardly a noticeable variation. Such magnificent results as were achieved then are hard to beat at any time. We do not hope to beat them. We can only hope to imitate them. They stand good for all time, and it is useful to recall them now and then in order to emphasise a truism which is occasionally overlooked by modern geographical explorers. It is not the most recent work in the field of exploration which is necessarily the most valuable. One of the great sins of omission in modern exploration is that of a failure to appreciate the efforts of preceding geographers in the same field of research as ourselves—the want of a patient absorption of all available previous knowledge before we attempt to add to the sum of it. We are not all of us gifted with the patient determination of that great traveller Sven Hedin, who spent three years in reading about Central Asia before he wrote a word on the subject. It cannot be too strongly urged in these days of narrowing fields for activity that although geographical research is essentially an active function of an active life it demands yet more and more, as time goes on, the application of the scholar added to the determined energy of the explorer.

Contraction of the World's 'Terra Incognita.'

It is, however, when we leave the high seas with their almost inexhaustible store of unexplored ocean floors and icebound coast-line, and turn from oceanography to the more familiar aspects of land geography that we find those spaces within which 'pioneer' exploration can be usefully carried to be so rapidly contracting year by year as to force upon our attention the necessity for adapting our methods for a progressive system of world-wide map making, not only to the requirements of abstract science, but to the utilitarian demands of commercial and political enterprise.

Asia.

Take Asia, for example: nearly half of the great continent pertains to Siberia, and within the limits of Russian territory the admirable organisation of her own system of geographical exploration leaves no room for outsiders to assist usefully, even if political objections did not exist. In Central and Southern Arabia there is undoubtedly still much to learn, but of the remaining countries which intervene between the Mediterranean and India, of Persia, Afghanistan, and Baluchistan, it can only be said that the work of the geographical pioneer has already ended where that of the engineer and surveyor has commenced. In the Furthest East again—in Manchuria, China, Tonkin, and Siam—there is much more room for the practical exploration of the road and railway maker than there is for the irresponsible career of the geographical traveller. The highway from China to India is almost as well known as that from London to India, and the activity of railway enterprise in the south of Asia bids fair to rival the triumphs of Siberia. It is only in the central deserts of Mongolia and the wastes of Tibet spreading southwards to the Himalayas that we can find untrodden areas of any great magnitude, and even in Central Asia before venturing on a statement of future possibilities in the field of exploration, it would be well to wait for the records of that most intrepid traveller, Sven Hedin, who promises us material of scientific and historical interest as the result of his last three years' travel far in excess of the monumental contributions which he has already made public. Historically the interest of the world of inquiry in Asia where we find the origin of the great races of the world and the birthplace of all religions must always be immense; but that history can only be elucidated by a clear illustration of the great highways of the Continent which were open to the vast migratory movements of mankind in prehistoric periods. We do not in the least understand the condition of climate, nor are we quite certain even of the relative distribution of land and water in High Asia in the days when its swarming population first began to flow south and west, carrying the elements of a language which we have been accustomed to regard as primeval into the swamps and plains which lay beyond the Himalayas or the Caspian. It is only through geographical research that some dim outline of those early stories can be realised; and although the researches of Stein and the marvellous discoveries of Sven Hedin around the ancient lake district of Lob Nor will, after all, only throw the world's history back for a few centuries, it is by means of these first steps backward that we can feel our way to an appreciation of the earlier processes of this phase of human evolution. Nor in the interests of utilitarian commercial speculation is geographical research in Asia yet to be set aside. We indeed know comparatively nothing of its resources in mineral wealth. It is quite within the bounds of possibility that one of the great central treasure houses of nature lies enveloped in the geological axis of the highest mountains of the world, and that we may yet be enabled to explain why every river which flows from Tibet washes down gold in its bed. But this will only be when the Tibetan Lama is prepared to shake hands with the Uitlander; and I fear that recent South African history will not encourage the embrace. Meanwhile there is no more promising field still open to the *bonâ-fide* explorer than that of Tibet and the farthest ranges of the Himalayas. Few people are aware how vast an extent of the Himalayan area still remains untrodden by any European. This is due to no want of enterprise on the part of our Indian surveyors and political officials. It is due partly to physical inaccessibility, and partly to that intense (and easily understood) objection to the interference of the stranger in which many of our transfrontier neighbours permit themselves to indulge. Nevertheless would I commend to those who still desire to walk in the rough and thorny path of pioneer geographical discovery a similar enterprise to that of our aforetime Secretary, Mr. Douglas Freshfield, who lately succeeded in passing beyond the bounds of official exploration into the Eastern Himalayas. We have had many travellers in the Himalayas, but they have not always distinguished between the fascinating pleasures of romantic adventure and the earnest pursuit of geographical business.

Study of Glaciers.

To Mr. Freshfield we certainly owe an introduction to a new vista of great scientific interest in the study of the formation and movements of glaciers. Here, perhaps, we are treading gently on the skirts of geological science; but I have never yet found that part of the world where the careful study of local geographical conformation will not inevitably invoke an inquiry into geological construction. We must accept the inevitable criticism and go on with our glaciers. Where in the world can there be such an area for research into the conditions of glacial formations as is presented by the Himalayas? I grant the physical and political difficulties in the way to which I have referred, but still well within the limits of our own red border there are glaciers yet to be studied, which if not the largest are yet large enough to satisfy the loftiest aspirations, and beyond that border the difficulties of approach are lessening day by day, and are no longer so formidable that they need hinder the steps of any determined explorer.

South American Glaciers.

The speculative interest in glacial movements and their influence on the geographical conformation become far greater when one moves in a country which has been recently shaped and polished, grooved and fashioned, by glacial action; when huge blocks of granite or porphyry, standing sentinel over terraces and ancient glacier-beds, witness to the passing of icebergs in prehistoric seas. Such conditions one may find in two widely separated areas—viz., in the Pamirs and in Patagonia. What causes led to the formation of the first vast ice-cap of which the glacier is the latest evidence? what caused its disappearance, its reappearance? why are the glaciers again withdrawing from the mountains? and what causes the universal process of modern desiccation, of which there is such ample evidence in the Pamirs, in Baluchistan, in Patagonia? It is to the Himalayas that we turn first for an answer to this question; but there are other fields almost equally promising, and one of them is to be found in South America. No one now can pretend any longer that we know nothing of Patagonia. Probably no country in the world has been described by so many geographers in so many different ways; there, at any rate, is a land of glaciers and snowfields awaiting research which presents few of the physical difficulties of the Himalayas. Here is a wonderful country truly, where glaciers reach down to the sea in low latitudes, casting little icebergs into waters fringed by green banks of fuchsia and myrtle and of bamboo; where the laurel grows into magnificent timber, competing with the Patagonian beech for root-hold on the moss-covered soil. The round grey heads of the granite hills, scratched and seamed by a discarded ice-cap on one side of the narrow straits balance the snow-bound peaks of the Cordilleras on the other. No physical difficulties bar the way to the investigation of glacial phenomena amidst some of the most striking coast scenery in the world. Near the parallel of 51° S. are two Patagonian lakes closely associated—Argentina and Viedma—which offer opportunities for the study of glaciers such as are probably not to be found anywhere else in the same latitude. For here the phenomenon of disappearance is in the stage of natural illustration. Glaciers are disappearing rapidly which but a few years ago seemed to be a permanent feature of the surrounding mountains, and the lake surface is chequered with their débris. There, too, may be studied for hundreds of miles northward the natural sequences of their disappearance—the formation of freshwater lakes and their gradual desiccation in turn—whilst all around there is the continued story of geographical evolution due to the alternate forces of glacial and volcanic action written in gigantic characters on the face of Nature.

Central South America.

Not very much has been added of late years to our practical knowledge of the hidden depths of Central South America except from the inexhaustible mine of information possessed by that eminent geographer Colonel Church. A Brazilian expedition in 1890; the explorations of a commission sent to investigate the interior with a view to the establishment of new political capital to Brazil in 1892–93; the discoveries of Dr. Ramon Paz in 1894, and a chequered journey in the Valley of the Orinoco by Stanley Paterson in 1897, form the principal records of modern days. There is doubtless much which is of the greatest commercial and political interest still to unravel in connection with the geography of the great river basins of the continent. But in South America we are threatened with perhaps the greatest development of what I may call artificial geography that the world has ever seen. Not only will the consummation of the Panama Canal project change the whole system of our western sea communications, and probably exercise a more enduring effect on the world's commerce than even the Suez connection between East and West, but the possibilities of linking up by a central canal system the three great river basins of the South—that of the Orinoco, the Amazon, and the Plata—is under serious consideration, and the mere project will in itself lead to an exhaustive examination of much untravelled country. Thus, even South America no longer offers a large field for the geographical pioneer of the future. With its narrowing areas of *terra incognita* and its almost phenomenal advance towards a leading position as the pastoral and meat-producing quarter of the habitable globe; with possibilities of development in this particular line probably exceeding those of Australia, New Zealand, and South Africa all put together, it is surely high time that South America turned her attention towards a combined and sustained international effort to place her scattered and most insufficient geographical surveys on a sound geodetic basis extending through the whole continent.

North America.

In the geographical fields presented by North America, as also by Australia, magnificent as are the opportunities for acquiring that personal acquaintance with the great depositions of nature which environ new conditions of life, and shape the course of human existence to its appointed ends, or, in other words, to acquire a geographical education from original sources of instruction, there is but little opening for the enterprise of the pioneer who aspires to show the way into new fields. There is no lack of native enterprise in colonies peopled by the stout-hearted descendants of generations of explorers. Neither Canadians nor Australians wait for England to show them how to develop the resources of their own country, or pilot the road to new ventures. On the contrary, we have to turn to Canada now for instruction in the higher art of geographical map-making, and to admit that England has been left far behind in the development of the special branch of science which deals with the illustration of the main features of geographical configuration in relation to their geological construction.

Africa.

In Africa the advance of our knowledge of the main outline of the geographical features of the continent has been so rapid since the days when the Nile was first traced to its source by Speke that a perfect network of explorers' lines of travel now embraces the continent in its meshes, and it is only in the intermediate spaces that room for enterprise on the part of the pioneer is left, even if it may not be said altogether to have vanished. A reference to the little map published by Mr. Ravenstein in the 'Geographical Journal' for last December will show you at once that the hydrography of Africa has been fairly well traced out in all its main arteries, leaving but few unexplored spaces of any great extent; and that such spaces, where they occur within the area which is especially open to Englishmen, demand an organised system of exploration more complete in its results, more carefully balanced in its relation to the geographical illustration of those lands which are beginning to form centres of civilisation than can be secured by the process of pioneer route making. In short, we want a system of geographical surveying allied to those systems which have been perfected after years of careful experiment by Canada, or Russia, or France, or by England in India. This, however, brings us into a field of technical inquiry of great importance, into which, so far as it deals with geography, *i.e.*, with the measurement of the earth's surface and the illustration of its configuration by means of maps, I propose to enter briefly in this Address.

Modern Requirements in Geographical Map-making.

You will agree with me that geography in the abstract, without illustration—the geography which used to be taught by geography books without maps—is but a poor and inefficient branch of academic knowledge, hardly worthy even of an infant school. It does not matter what branch of this comprehensive science you approach, whether it is historical, or physical, or political, modern or ancient, the only substantial presentment of the subject to man's understanding is that which has recourse to map illustration. Words (especially words bearing such indefinite applications as our modern geographical terminology) can never convey to the imagination the same substantial illustration as maps convey to the eye. You may think that all this is mere truism; so it may be; but I assure you that what I may call descriptive geography, that is to say, geography without the aid of maps, has more than once nearly precipitated national disaster in quite modern times—disaster quite as perilous as any which in military fields has been caused by blank, wholesale ignorance of the features of a country in which strategic movements are undertaken. There comes a time in the history of every developing country when the increase of its people, and the consequent distribution of land, demands surveys for the purposes of fiscal administration. Consequently such surveys are common everywhere; and from these have been built up, piece by piece, like a child's puzzle, the geographical maps of many half-occupied lands, illustrating only such portions as are adaptable to economic development, and leaving blank all that promised to be unproductive and unprofitable.

Field of Geodesy.

It was only when it was discovered that the sum total of such a production was apt to cause great confusion in land assessment, inasmuch as it often did not equal the actual area of the land distributed, that there arose a school of mathematicians who concerned themselves with determining the dimensions and figure of the earth, and founded that apparently complicated system of primary map-making which now takes count of such matters as the curvature of the earth's surface, the convergency of meridians, and other spheroidal problems which affect the construction of the map. Thus arose 'geodesy,' and geodesy has numbered amongst its apostles many of the greatest mathematicians of the age. Geodesy, the science which deals with exact measurements, was never an embodiment of abstract mathematical investigation. It had always a utilitarian side to it, and it is unfortunate that this view of the science has been occasionally lost sight of in late years. For we have not done with geodetic investigation yet. Magnificent as are the results obtained by the mathematicians of the past, there are still further refinements to be introduced into those factors which we daily use for the reduction of our terrestrial observations ere we obtain perfect mathematical exactness (if we ever attain it) in our results; and we still must look to the processes of geodesy to give us that backbone, that main axis of indisputable values from which our network of triangulations may spread during the first steps in geographical map-making. To a certain extent geodesy is the support of technical geography, and a short inquiry into its present conditions of existence may not be out of place.

It is to North America that we must now turn for instruction in the latest development of the science, and to South Africa that we must look for its future application. Russia has not lost sight of the necessity imposed on her for an extension of her magnificent European geodetic system through the vast breadth of her Asiatic possessions, but we ourselves in India are concerned nowadays rather with scientific observations on collateral lines, and with the collating and perfecting of the results attained by the great achievements of past years, than with any developments in fresh fields of geodetic triangulation. Germany and France, ever alert where colonial interests are concerned, are busy in Africa, but I am not prepared to say how far their geographical efforts are based on the strict principles of geodesy.

In North America, along the meridian of 98° through Texas, Kansas, and

Nebraska, geodetic triangulation still forms one of the most prominent schemes of modern work undertaken by the Coast and Geodetic Survey; and in South Africa there is growing northward into the Transvaal slowly, but we hope surely, the framework of a gigantic arc which one day will be extended by Sir David Gill from the Cape to Cairo.

I am anxious to impress on you that the science of geodesy is not a science of the past. It is still active, and with all its refinements of minute accuracy and exact precision in observation and in calculation, it should be the initial mainstay, and it must be the final court of appeal, as it were, for all those less rigorously conducted surveys of the reconnaissance and exploration class which we term geographical.

But this accurate framework, this rigorously exact line of precise values which ultimately becomes the backbone of an otherwise invertebrate survey anatomy, is painfully slow in its progress, and it is usually haunted by the bogey of finance. It does not appeal to the imagination like an Antarctic expedition, although it may lead to far more solid results, and it generally has to sue *in forma pauperis* to Government for its support.

Geographical Surveys.

And thus it happens that long before the tedious and expensive processes which are involved in the term geodetic triangulation can possibly be carried to an effective end the cry goes up for a geographical survey. It is wanted by the administrator to whom it is all important that he should know the roads and river communications, and the productive areas of the land he has to administer, and be able to locate the various tribal sections or peoples with whom he has to deal. In the political department a geographical map may be said to be absolutely necessary for the political purpose of defining limits and boundaries. It has been, I am aware, occasionally dispensed with, but never with satisfactory results. To the officer on whom rests the responsibility of preserving peace and good order it is most desirable that the military features should be fairly represented in such a manner that at least a general plan of action can be arranged at short notice. For the economic development of the country it cannot be too strongly urged that a general geographical outline of its surface is indispensable to the selection of lines for special technical examination, whether for roads, railways, canals, or telegraphs. How often lately in the history of our colonial or frontier progress have vast sums been expended on special lines of railway in ignorance of the fact that better alignments of infinitely less physical difficulty would have been at once revealed by a general geographical map even on the smallest scale? In short, the cheapest, the quickest, the surest, indeed the only satisfactory method of regulating the progression of public works, the development of commerce, the proper recognition of the frontier boundaries, the administration of justice, and the military control of a large and growing colony, or of a long stretch of military frontier, is to be armed with a perfect summary of what that country contains in the shape of a geographical map; and yet it is only quite lately that this fact has been recognised by English administrators and English generals in their dealings with new colonies and new frontiers. Russia learnt the lesson a generation ago at least. When she reached out a hand for Constantinople her army was accompanied across the Balkans by whole companies of surveyors, who worked on no sketchy system of indicating lines of route here and there. They pushed at least seven series of triangulation across the mountains, and on that as a basis they mapped the whole country in detail on a good military scale (about an inch per mile) right up to the very gates of the Turkish capital. For years her brigade of topographers has been busy along her Afghan and Siberian frontiers. In Persia, Baluchistan, the Pamirs, and China, wherever in fact there may be in the future some prospective view of a closer political, commercial, or military interest than exists at present, there they are to be found. France has always been strong in the geographical field, and the late achievements of Frenchmen in the world of exploration and of exploratory map-making are only equalled by the scientific knowledge and literary ability displayed in their technical literature on the subject. Colonel Laussedat's contribution to the 'History of Topography' is to be reckoned with as a standard work. In Canada and North America we have perhaps a practical exposition of the art of geographical surveying which is as unequalled in completeness and comprehensiveness as the country with which it has to deal is unequalled as a subject for its application. There the close association between geological structure and geographical conformation is so fully recognised that the same technical process of surveying is applied for the purpose of the double illustration. The Canadian geological survey is their geographical survey, and I think that it is to Canada (if not to India) that we owe the first recognition of the fact that geographical surveying is a separate, distinct, and most important branch of the general art, which should form the basis—the mother survey as it were—from which all other surveys should spring. In India I am happy to think that this advance in the science of geography is now well understood. It has been more or less forced on us by the necessity for such rapid and comprehensive surveys as are required for frontier military operations, for the purposes of boundary demarcation, and for the important duty of keeping our own trans-frontier information up to the level of that of our neighbours. In our African colonies it has, alas! been discovered a little too late that geographical surveys are a sound preliminary to military operations, but the discovery once made it is not likely to be overlooked. Here, indeed, was presented a most forcible illustration of the danger of building up a geographical puzzle map; of piling one on to another the results of local fiscal surveys in the hope that when they were all put together they might make a good topographical guide to the country. Needless to say the result was disastrous from the scientific point of view, and it might almost be said of it that it was disastrous from the military point of view as well. Imagine for an instant that the Canadian system of a geological survey (involving of course accurate topography) had been applied *ab initio* to South Africa, who can possibly say what the result might not have been by this time? The expansion of the Randt mines, for example, depends at present on local experiment carried out no doubt by most able engineers with all the knowledge of scientific mining that is to be acquired in these days of advanced specialism. But all the same I may be permitted to suggest that their experimental ventures, their tentative borings, are subject to a good deal that is almost guess work for their application, and that a comprehensive, carefully conducted geological survey of the whole country would probably have afforded valuable indications in many unexpected directions. So also as regards schemes for local irrigation. Take the north-western part of Cape Colony, for instance, the district known as the Karoo, where the best military map existing at the time of the war did not even pretend to show the main roads through the country. The stage of development at which that part of the colony has arrived in the all-important matter of local irrigation is only worthy of the Dark Ages. It would be laughed at in Persia or Afghanistan. The Arabs of mediæval times were experts in the art of the conservancy and distribution of water in dry lands compared to the modern South African (or South American) farmer. Now I do not say that schemes for merely local irrigation require geographical maps to support them. Such schemes only require a little enterprise, a little common sense, and a little capital, but I do say that the geographical map would long ago have revealed the opportunity for comprehensive schemes, such as exist in India, just as it would have pointed out the best alignment for roads and railways, the best means for dealing with an enemy who can move fifty miles in a night, and who can make, not merely a few square miles, but a whole district the theatre of his operations. What was wanted (and is still wanted) in South Africa is what is wanted in every part of the continent subject to British suzerainty. I know that I am but echoing the urgent demand which has been made by every commissioner and governor within the limits of that vast area—not for elaborate or special maps for fiscal and revenue purposes, all of which will come in due time—but for scientific geography which shall now take the place of the preliminary work of pioneer explorers, and deal with the country as a whole instead of tracing it in outlines and in disjointed parts. In short they require all gaps filled up. They want to know what the country contains in the way of forests, of open land suitable for agriculture, of desert and swamp, of opportunities for roads and railways, for telegraphs and irrigation, before deciding on the right position for the centre of an arterial system of public works which shall pervade in natural and orderly sequence, and in due time, every part of the body of the country of their administration. Now this is scientific geography. It is not ordnance map-making nor anything very much like it. It is a comparatively new demand on the scientific resources of England, and those resources are by no means equal to the demand. Before considering resources, however, we must look to the scientific means to this geographical end. I have already referred briefly to the subject of geodesy, and I have told you that what is termed geodetic triangulation is a function of high scientific order, demanding not only minute and painstaking care on the part of an able staff of observers, but very considerable time and very considerable expense to carry it to a satisfactory issue. I have also pointed out that inasmuch as the exact distribution into parts of any large space of the world's area must ultimately depend on the exact measurements which are a function of only the highest class of geodetic triangulation, we must look finally to geodesy to support the framework of our geography and to give it its rightful place in the great total of the world's mapping. But the demand for geographical mapping is not satisfied with the promise of an elaborate basis for the work which has first to be constructed with the expenditure of much time and money before anything in the nature of a final map can be produced for purposes of administration. The political world, too, cannot always sit patiently through all the international disagreements, the losses, the unrest, and the positive national danger to which an unsettled boundary gives rise, whilst the geodesist works slowly through the country year after year, piling up sheaves of equations and folios of observations, but never a square mile of practical topography. As for the military department I hardly know what to say. There is the example before us of Germans, Russians, French, and Americans, all conducting their campaigns with maps in their hands, taking every special means at their command in order to acquire such maps before they commence operations; whilst the Boers have fought us to the bitter end with a practical knowledge of the country which is even better than maps, and which is exactly that class of knowledge which maps are supposed to replace or supplement. None of them wait for geodesy.

Certainly the attitude of the military department is not one of neutrality. They would like the maps, they are even anxious to get them, but they are not quite certain that they are worth paying for. However that may be, I can only express my own conviction that geographical mapping will be found to be an urgent necessity in every corner of the unmapped world subject to British influence. We would like to wait for those accurate determinations of geodesy which would at once furnish us with the best of all possible means for commencing a comprehensive geographical survey. But we cannot afford to wait, and the great geographical problem of the age is how to reverse the natural sequence of scientific procedure and to obtain maps of the unmapped world which no subsequent geodetic operations shall condemn as inaccurate. It is not a question of expediency; it has been one of necessity for many years past; and inasmuch as necessity is the mother of invention, I think that it will finally be conceded that means *have* been found for ensuring sufficient accuracy in geographical work to render it capable of enduring the subsequent tests of completed geodetic measurement without dislocation and without interference with the general utility of the maps, even if that accuracy be not scientifically perfect.

It is not my intention to bore you with technical details. I only wish to impress upon you that in the field of scientific geography, as in other fields, 'the old order changeth.' We must work on new principles in order to meet new demands.

Use of the Telegraph in Geography.

One of the chief means to this end is the telegraph. Few people appreciate the important rôle which is played by the telegraph in these days in the field of geography. It was not so very long ago that the first step towards regenerating a natural wilderness, or for securing access to new commercial openings or centres of uncivilised population was held to be the construction of roads and railways. Means of physical access was the first step towards the development of a country which was regarded as unenlightened from the standpoint of European civilisation. It is so no longer, for the telegraph often threads its way through many a dreary waste of unpeopled earth, uncoiling its length for hundreds of miles in advance of any railway, or indeed of any road, which can in the ordinary sense of the term be described as a constructed road. I will give you an illustration. On the Patagonian pampas not so very long ago, in the midst of a wide wilderness of snow, after losing our way in a blinding snowstorm and camping on our tracks for the night, we struck the end of the telegraph line which is now being pushed across Patagonia, and which will eventually connect the Atlantic with the Pacific. We had seen no roads whatever for a great part of the distance we had traversed. Our daily procedure was the simple process of following a guide over the illimitable stretches of bush-covered uplands which reach down from the eastern foot of the Andes in gentle grades to the Atlantic shore; and when we did at last fall in with the great central line of trans-continental communication we found it to consist of the wheel-marks of certain previous waggons which had drifted along that way, a sort of road which it was exceedingly easy to lose in the fading light of a stormy winter's day. On this road there was nothing but a telegraph end and the tents of a few telegraph officials, and we were some 150 miles from our destination on the Atlantic coast. And so it happened that after weeks of absence from any means of communication with the outside world we were thus suddenly put in possession of its very latest news; and the very first message that passed from the end of that line into my hands was the message of peace with South Africa, signed an hour or two previously. I accepted that message as a happy omen for the result of our Patagonian mission. And thenceforward (thanks to the courtesy of the telegraph chief at Buenos Ayres) nightly as we sat in the snow we read all that was important from the London evening papers of that self-same day. We were not starving by any means, but had we wanted a loaf of bread in that unbroken stretch of snow-covered bushland we certainly could not have got it; whilst here was information flowing in with a daily ease and regularity that I greatly missed when once again I was within reach of clubs and civilisation. The importance of telegraphs in the field of geography, however, is not confined to the transfer of news to casual travellers. It is the facility which it places in the hands of the geographer for determining his position in longitude that renders it so important a factor in the prosecution of a geographical survey. Everyone knows that the first duty of a geographer is to discover his latitude and his longitude. Hitherto the determination of the first has been a matter of no great uncertainty, but, as regards the latter, one can only say that the confidence expressed by most explorers in the results of their observations has never been justified by the final verdict of subsequent determination. It is, in truth, most difficult even for the most practised observer to obtain an absolute value in longitude on which he can rely within such limits of accuracy as are essential to the construction of a map where these values have to be employed differentially. The telegraph places in our hands the means of differential determinations within a degree of exactness that surpasses even that of the most careful determination of latitude; and the telegraph is everywhere. Supplementary to the facilities of time-signalling by telegraph is the wonderful accuracy of graduation introduced into the smaller classes of new instruments which in these days replace the cumbersome equipment of the past. With a small 6-inch theodolite fitted with a complete vertical circle time values can be determined within a fraction of a second, and latitude values to within two seconds of arc, always provided that that great bugbear of he astronomical geographer, level deflection, does not interfere with his results. But the same minute accuracy in graduation which has so improved the ordinary ittle instruments which you find in the hands of the professional geographer has, when combined with new methods for accurate linear measurement, also placed t in his power to carry out a fairly coherent and systematic triangulation with great rapidity and accuracy over large areas of country whenever the configuration and characteristics of that country are favourable. Usually they are favourable. Large expanses of flat desert, of undulating veldt or of unbroken forest are the exception, not the rule, and they must of course be dealt with as their special peculiarities demand; and for the normal conditions of land configuration, given that the explorer is specially careful about his base measurements and his initial data, he can certainly with modern instruments and the facilities for check given him by the telegraph, carry on a rapid and comprehensive geographical survey which will fulfil all the conditions required by the administrator, economist, political geographer, or military commander within such limits of accuracy as will ensure its standing all the subsequent tests that geodesy may apply without any apparent map dislocation. And practically that is all that is wanted for a first map. I have used the word 'rapidly.' Few people (even scientific geographers) have really grasped the full meaning of the term as applied to surveys on geographical scales (*i.e.*, 1 : 250000, or about four miles to the inch, or less) under normal conditions. Such surveys can be completed quite as fast as an army can advance in the field, even granting that the advance is continuous. They can even to a certain extent precede that advance in face of an enemy. A single triangulator with a staff of two or three topographers in a fairly favourable country will be responsible for an outturn which may be counted by hundreds of square miles per day. The records of both American and Canadian surveys will prove that the marvellous progress made in the frontier reconnaissance surveys of India is nothing abnormal or unexpected.

Necessity for Training Schools.

So far I have spoken about the system only, a system which has been nearly perfected by experiments in Canada, Russia, India, and elsewhere. Now we have to turn from the work to the workmen. It is only lately, quite lately, that England has discovered that such workmen are wanted at all. Five or six years ago there was not a topographer nor a topographical school in England. But the demand during late years has been insistent and constant, with the result, I am glad to say, that efforts have been made in various directions to start topographical schools, and a distinct change is apparent in our methods of instruction at military headquarters. No purely technical central civil schools such as exist on the Continent are to be found in England, and the natural result is that at present England possesses no finished topographers and not many men who know what is meant by a geographical survey. In the wilds of Patagonia (which is, I must premise, a country beset with special climatic difficulties, but not otherwise one unsuitable to the topographer's art) I met many men of great intelligence and exceptional skill who had been gathered from various quarters for the purpose of topography. There were Italians, Argentines, Germans, French, and Swiss, but not an Englishman amongst them. Russians of the type of my old and unforgotten friend Benderski have long been famous for their skill; but although English administrators and soldiers are alike crying out for more and better assistance in the active field of topography they cannot get it from England. The establishment of a school of practical geography such as must eventually guarantee the existence of a military topographical corps would be a matter of congratulation deserving to be noted as an important step in the advance of the geographical education of the country, no less than the school at Oxford which deals more directly with civil interests, and is rightly most concerned with the academic aspects of geographical instruction. Even this, however, is hardly sufficient. I am convinced that the recommendation which arose from certain resolutions found in the Geographical Section of the British Association Meeting at Bradford two years ago in favour of the employment of natives in Africa for African work, just as Indian natives are employed in India, is thoroughly sound. We want schools in Africa as well as in England. Only in this way will the vast areas still unmapped in our African protectorates be dealt with at reasonable cost and in a reasonable space of time.

Photo-topography.

Certain developments in the practical field of geography have lately been brought to the test of continued experimental application, and the progress of these experiments deserves a passing record. Notably the application of photography to purposes of geographical illustration has received immense impetus from the apparent facility with which the experimental media can be handled. In favour of the haphazard landscape illustrations with which we are usually deluged by travellers there is little to be said. They are far more frequently illustrations of the personal progress of the author than of the general character of the country he progressed through. Neither is there much more to commend in photographs designed to reproduce geological or tectonic features, glacial configuration, special orographical conditions, or the like unless the position of them and the direction of the line of sight from the point of view are very clearly indicated on a corresponding map. At the best they are apt to be deceptive, for the reason that they can but deal with one side of a subject and with only a partial view of the particular feature they represent. Everyone knows that an apparent range, or even a system of ranges, of mountains may be nothing but the *revêtement* of a high plateau or tableland; but the photograph of such a mountain system will give no indication of the plateau beyond the range which can indeed only be determined by a survey, and properly illustrated by a map. I need hardly say that a topographical delineation of ground derived from observations made by the aid of photography demands as much technical skill on the part of the topographer and as much systematic application of the use of instruments as any other survey. It must be a combination of careful triangulation and skilful plane-tabling precisely as is the product of a topographical survey. It demands, if anything, more special training and a more elaborate method of procedure than does ordinary survey. So far as the results of experiments made over suitable fields in Canada can teach us, the verdict is in favour of the process only under certain conditions of light and climate when it is desirable to obtain a record of observations in as short a space of time as possible, either in high altitudes, when passing clouds afford but a fleeting view of the landscape, or in low-lying districts, where active tribal hostility in the field or some similar condition renders it desirable to curtail operations as much as possible. Under all other ordinary conditions it is maintained by Canadian surveyors that although both time and labour may be saved on the field operations, the resulting map can never attain the same standard of accuracy in detail that distinguishes good topographical illustration of the usual variety of natural features. I am, of course, now speaking of geographical surveying as an art, not of mere geographical exploitation. In the latter case doubtless every traveller who can 'pull the string' in these days can add immensely to the personal interest of his journeys by his illustrations of them. But I would earnestly impress upon all travellers that if they desire those illustrations to be of any use for geographical compilation it is absolutely necessary to know the point from which they were taken and the direction of the view.

Barometric Records.

Once again too would I warn travellers of the utter uncertainty of all classes of barometric determinations for altitude. Very little has been done in recent years towards improving instruments of the barometric class, and meteorological science has not yet taught us how to deal with the constant variations in air pressure produced over local areas by changeable weather. There are some countries where barometric records can hardly be regarded as offering a clue even to differential heights. It cannot be too often insisted on that the determination of the relative heights of mountain peaks and of the local value of refraction by means of the theodolite is as much the duty of the triangulator as is the fixing of those peaks in position for the use of the topographer. From these again the altitude of positions in the plains can be safely determined by small instruments of the clinometer class without resorting to the barometer at all, although it may still be necessary to ascertain the value of one initial (or final) point which must be determined by many observations spread over a considerable length of time and synchronous with another set of observations determined at sea, or some already known, level. This of course will occur only when a new geographical area is opened up to survey at some distance from the sea.

Universal Mapping.

It will be remembered that a scheme was set afloat some years ago by Dr. Penck, the eminent German geographer, for the mapping of the whole world on the scale of one-millionth, which is very nearly equivalent to the scale of sixteen miles to one inch. Substantial progress has now been made in support of this scheme by English map-makers, especially in India, where all the trans-border countries which have fallen geographically into the hands of Indian surveyors are now being mapped on this scale. In the commencement of all great colonial survey schemes it is much to be hoped that this project for one homogeneous and universal map will not be lost sight of.

Map Spelling.

I wish that we were as well on the way towards homogeneity in spelling as we are in scale; but it is much to be feared that arbitrary rules will have to be applied to so many special localities that no universal system is ever likely to be adopted. The further that exact geography extends the more difficult becomes this problem, until at last we shall probably arrive at the conclusions adopted long ago by the Government of India, and consider it best to lay down by order an arbitrary list of prominent names, and rule that the spelling of them shall be maintained as in this list in all Government records and maps. Scientists may disagree, but after all it seems the only practical way out of the confusion that exists at present.

Terminology.

There is yet another subject of world-wide interest to the geographical student equally with the practical geographer which requires something of the erudition of the philological scholar to be brought to bear upon it in order to arrive at a satisfactory issue. I refer to the subject of geographical terminology. It may seem an easy thing to be satisfied with such general definitions as are involved in the terms 'range of mountains,' 'coast lines,' 'main channels,' 'watersheds,' 'slopes,' 'affluents,' and the like; but when these terms, and terms similar to them, are employed in international agreements and treaties, carrying with them the necessity for identifying on the face of nature the feature which corresponds to the term employed, there is always to be found room for discussion as to what its exact meaning may be. For the variations of nature are infinite, and no two features classified under the same generic name are alike. Were I to give you examples of only a few of the geographical expressions which, carelessly used, have led up to serious international disagreements you would, I am assured, agree with me that it is high time that geographers all the world over came to some definite understanding about the meaning of geographical terms. To take an instance. What is a 'range' or a 'main range' of mountains? Where does it begin? Where does it end? How far does the term involve geological structure? When a continuous line of similar structure is split across the axis of it, does it become two ranges or does it remain one and the same range? Or, again, what is 'the foot of the hills'? Is it where the steep slopes end and the talus or gentle gradients of its detritus commence, or must you follow the latter down to the nearest watercourse? If you talk of the coast line of Western Patagonia or of Norway do you include such headlands as are connected with the mainland at low water, and exclude the islands, or do you mean the coast line of both? What is the main channel of a river? Is it where the flowing water scours deepest from time to time, or is it a fixture amongst a score of minor channels that shift and change? Perfect definition is of course hopeless. It is not in the power of man to deal with all the infinite variations of geographical feature and to classify them as he would specimens of botanical origin or of natural history. But we might arrive at a much more satisfactory dictionary of geographical terms in our own language than at present exists, and we might offer that dictionary to the geographers of the world at large and say, 'Here we have at least endeavoured to explain our meaning when we make use of geographical expressions. This is what is taught in our schools as the best means of translating the general idea into a distinct mental conception of natural features; and in future when we use these terms you will know on the best authority that England can produce what it is that we mean by them.' Then possibly instead of having to turn to Germany and France for assistance in expressing ourselves clearly when drawing up legal documents dealing with geographical conditions, we may find the English language become the standard for this special class of literature in spite of its verbal poverty. This at any rate is what is now being attempted by the Geographical Society, which spares no effort in order to obtain the best literary assistance in its compilation that the country affords. We shall soon have a geographical dictionary, I trust, and be able to enter with a little more ease and confidence into the field of literary discussion of geographical subjects.

Progress of Geographical Education.

The progress of geographical education in the country, although it is by no means so universally apparent as might be considered desirable, yet shows encouraging symptoms of vitality in many directions.

The Civil School at Oxford, for instance, conducted by Mr. Mackinder, has already made most successful efforts to produce expert teachers of geography. Here, in addition to 208 students, of whom 163 were men attending courses during the past year, five students have already won the Post-graduate Diploma granted by the University, and it is encouraging to note that four out of the five have already obtained distinctively geographical work. Others similarly qualified, if of sufficient ability, would probably not have long to wait for opportunities. In addition to its regular University functions, the Oxford school has this year organised a summer course of three weeks' study. This has been well attended by teachers and instructors from all parts of the country, and even from America.

In London a department of economic geography is in course of organisation at the School of Economics and Political Science, and geography will become a compulsory subject in examinations. In the matter of examinations we have to chronicle the issue of a most excellent syllabus for the new London Matriculation which should ultimately have great influence on the teaching in many schools.

Further, the 'Geographical Association,' a body now of several hundred teachers, has made great progress. It has recently commenced the issue of a journal known as the 'Geographical Teacher,' one of whose functions appears to be the criticism of the questions set in various public examinations.

Satisfactory progress has also to be recorded of the school of surveying initiated by the Royal Geographical Society, now under Mr. Reeves. The diploma has been awarded to a number of candidates (about twenty-five) who have passed through the school, who have invariably found suitable employment as surveyors subsequently. Indeed the demand for trained R.G.S. surveyors already exceeds the supply, although it cannot as yet be maintained that our means of training are as perfect as we could wish.

In military schools the report of the late Committee appointed to Consider the Education of Army Officers shows clearly enough that amongst all the necessary subjects for a cadet's education which have to be crammed into the exceedingly short course of his military schooling that branch of geography which is embraced by the term 'military topography' finds a very conspicuous place. The short course of a military school will never turn out an accomplished geographical surveyor; nor does it in any way outflank the necessity for a military school for professional topographers. But it teaches the young officer how maps are made, and instructs him in the use of topographical symbols. It would be well if it could be pushed a little further—if it could teach him how to make use of the maps when they *are* made—for personal experience convinces me that the apathy shown by many of our foremost generals and leaders on the subject of maps arises chiefly from a well-founded doubt of their own ability to make use of them. As for the broader basis of general geographical instruction which would deal with the distribution of important military posts and strategic positions throughout the Empire, and teach officers the functions of such positions, either individually or in combination, during military or naval operations, it is perhaps better that such a strategic aspect of geography should be relegated to a later age, when the average intelligence of the cadet has become more fully developed.

Taking it for all in all there are distinct signs of a more general interest and more scholarly standard of thought in the subject of geography. This is probably due to the efforts of a comparatively small group of workers at a time of general educational reform, possibly partly stimulated by the disclosures in connection with the late war.

The methods of further improvement are simple—better teachers and better examining—and for both it is probable that we must look more directly to civil sources than to the tentative efforts of the military schools.

The following Paper was read:—

1. *The Geography of Southern Persia as affecting its History, together with a Brief Account of the Helmand Delta and the Great Desert of Persia known as the Lut. By* Major P. MOLESWORTH SYKES, *C.M.G.*

Southern Persia and Baluchistán lie between the rich alluvial plains and ancient civilisations of the Euphrates, Tigris, and Kárun on the west, and that of the Indus on the east. Washed throughout to the south by the Persian Gulf and Arabian Sea, the country maintains a low level for a considerable distance inland and the heat in summer is terrific. Additional disadvantages are the absence of good harbours, and the fact that in the Persian Gulf there is always either too much or too little wind. This coast strip runs back to range after range of rugged mountains, increasing in altitude until the Irán plateau is reached. The fertile zone of upland country is not very wide, and it soon decreases in elevation, sloping down to the paralysing waste of the Lut.

The characteristics of Baluchistán are to a considerable extent similar, except that the altitude of the mountain chains is not so great. As cultivation depends on irrigation, the absence of ranges sufficiently lofty to serve as storehouses for snow results in the encroachment of the Lut much farther south. Indeed, the eastern border of the Kermán province is separated from Baluchistán by a section of this desert some 200 miles in width, which is an important factor in the history of Southern Persia. In its east and west aspect, from the Tehrán-Isfahán-Shiráz-Bushire road eastwards, the Lut stretches right across the entire width of Persia, thus separating the land of Irán into two divisions far more effectually than any sea or mountain barrier. To summarise, Southern Persia and Baluchistán have ever been comparatively barren countries, most difficult of access from the coast, and consequently have always escaped invasion by sea. Owing to the hardening influence of a livelihood gained from a sterile soil, and perhaps still more to the superb climate, a warlike race was produced, which frequently held in subjection the inhabitants of the rich low-lying plains to the west, while more than once the martial hosts of Irán have swept all before them in the plains of India.

Concerning the variable lower course of the Helmand, the author gained some interesting details when travelling in Sístán nearly four years ago. Indeed, it must be recollected that Sistán is not only fed by the Helmand, the classic Etymander, but that its waters form the lagoon in which this interesting river discharges. To summarise the courses taken by the Helmand, in the fourteenth century there was a solid dam, known originally as the Band-i-Rustam and later as Band-i-Akwa (evidently a corruption of Afghan or Agwan). This was situate at a point on the Helmand some forty miles east of the ruins of Hauzdár, and at an equal distance from the limits of Sistán as it is to-day. A deep canal running west irrigated the fertile plain of Hauzdár, the main stream flowing north under the name of Rud-i-Nasru. On its banks were the famous cities of Shahristán and Zahidán. Towards the close of the fourteenth century Sístán was invaded by Timur or Tamerlane, who destroyed the dam, and thus reduced the Hauzdár plain to a waterless desert.

The Helmand, while still keeping to the Rud-i-Nasru, created a second branch encircling Sehkuha, which had not hitherto been inhabited. There was apparently no other change until early in the nineteenth century, when the whole volume of water united to carve out a channel farther east, to the west of the village and mound of Nád-i-Ali. As cultivated Sístán was thereby left high and dry, the Rud-i-Sistán was cut a little to the north of Sehkuha—a task of great magnitude. This was the state of affairs when Sir Frederic Goldsmid made his award; but in 1896 the Helmand began to forsake the Nád-i-Ali channel, and struck out a new course between it and the Rud-i-Nasru. This is now known as the Rud-i-Perián, which was a fine river when the author crossed it on a reed raft in 1899. It is anticipated by the greybeards of Sístán that the wayward Helmand will finally return to the ancient Rud-i-Nasru.

The Lut, undoubtedly the salient characteristic of Persian physical geography, is believed to have been in early times an inland sea, which theory is supported by the presence of the active volcano of Sarhad, the extinct volcano of Bazman, and many legends. Careful inquiry has led the author to believe that the name Lut properly applies to the whole of the great desert of Persia, including the so-called Dasht-i-Kavir in the north and the Dasht-i-Lut in the south, and that its saline portions are known as Kavir, which is undoubtedly the Arabic word *kafr*, signifying a saline swamp. As regards the term Lut, the guides point out fantastic bluffs, resembling forts, mosques, or cathedrals, and explain how they are ruins of cities which the Almighty destroyed, as was the case with the cities of the plain, from which Lot escaped with so much difficulty. Furthermore, Luti although now used to designate a buffoon, formerly meant a Sodomite. It would seem that this great waste of Persia has become associated (most appropriately) with the name of Lot, Abraham's nephew.

The author finally made some remarks on the trade routes and on the telegraph line which is being constructed across Persia, showing how, in every case, direction was determined by geographical features.

FRIDAY, SEPTEMBER 12.

The following Papers were read :—

1. *Yünnan.* *By* Captain C. H. D. Ryder, *R.E.*

Of the eighteen Provinces into which China proper is divided, Yünnan, though one of the largest, is one of the least populated. It is one mass of hills with small plains nestling among them, in which reside the Chinese, who leave most of the hilly country and the deeper valleys to the original inhabitants, such as Lolos, Shans, &c.

There are some seventy walled cities, many of them cities only in name, each plain as a rule containing one city, the official centre of the district.

From a geographical point of view the most interesting feature is the extraordinary number of large rivers which flow through or rise within the province, affluents of the Iráwadi, the Salwín, Mekong, Yangtse, West River, and Red River; the second, third, and fourth of these, as they enter Yünnan all flow in deep valleys side by side for many miles, barely twenty miles one from another, with a huge mountain range intervening. Farther south these rivers separate, allowing room for the headwaters of the Red and West Rivers, the centre of the Province, the watershed between these various river-systems thus forming an elevated plateau, the plains on which are mostly about 6,000 feet in elevation. The climate varies according to the elevation from perpetual snow to perpetual heat, with every intervening stage; consequently the fauna and flora, and the produce of the fields, vary considerably. The seasons are well defined—rains, cold weather, and hot weather; the former the least pleasant, especially to travellers. Trade is nearly at a standstill owing to the shocking condition of the roads and the unhealthiness of the valleys, which are held in great awe by the Chinese merchants. The hills, except in the neighbourhood of the towns, are well wooded and abound in small game, though the larger wild animals are conspicuous by their absence. A large quantity of minerals exist, mines of copper and silver—some worked, others deserted—being constantly met with.

Situated as it is in the south-west corner of the empire, with French territory on the south and English on the west, much attention has been drawn to Yünnan, and after various schemes had been propounded for tapping the trade, the Yünnan Company fitted out an expedition under Major Davies—to which I was attached by the Government of India to survey and report on Yünnan—with a view to deciding whether a line of railway was possible from Burma into China. This we successfully accomplished in two successive seasons; but, owing to the mountainous country and the poor prospects of traffic, it has been decided to abandon any idea of a railway on these lines. In a short time a railway will be completed, but it will be from Tongking and not from Burma.

Yünnan is as regards scenery the flower of China and most pleasant to travel in, always excepting certain rudeness, which everyone must expect, from the Chinese themselves.

2. *Colonisation and Irrigation in Uganda and the British East Africa Protectorate.* *By* R. B. Buckley, *C.S.I.*

This paper commences with a description of the climate, and a statement of the rainfall, in the British East Africa Protectorate. A brief description is also given of the Uganda railway, which is mentioned as a monument to the skill of its engineers. The political and local effects of the railway are referred to.

The paper refers to the climatic conditions which affect Lake Victoria Nyanza, and has an Appendix showing the rise and fall in the surface of the lake since 1896. The causes of the fluctuations in the lake are discussed, and it is shown that the volume of water which is actually available for storage in the lake for purposes of irrigation is not so great as might be supposed.

The Uganda railway passes through the high lands of East Africa, where a tract of land, the size of England north of Liverpool and Sheffield, lies at an elevation of more than 5,000 feet above the sea and has a pleasant and temperate climate. There seems to be no doubt that this country is eminently suited for colonisation, and that, if it could be irrigated, nearly all European crops and fruits could be grown in it.

The paper discusses the possibilities of irrigation in East Africa, which do not seem very hopeful. The three main rivers, the Juba, the Tana, and the Sabaki, are not well known and their discharges at different times of the year are not recorded. The rivers are navigable in their lower reaches near the sea. It seems likely that irrigation from the Juba and Tana might be possible in the higher lands, and that 30,000 or 40,000 acres might be irrigated from the Sabaki, just below the point where the Tsavo River, which is fed from the snows of Kilimanjaro, joins the main stream. But the paper points out that the area commanded lies within the field of action of the tsetse fly, which might make cultivation difficult, if not impossible.

Reference is made to the great Taru wilderness, which has absorbed so many human lives, and the possibility of irrigating it is considered.

In the tract of land, lying about 5,000 feet above the sea, through which the Uganda railway passes, there are no rivers of any magnitude; and the discharge, in the streams which do exist, is very uncertain. It is shown that the area which might be irrigated by the perennial discharge of those rivers which have a constant discharge would be quite insignificant, and that the only way to irrigate effectively would be by the construction of reservoirs in the hills. These reservoirs would not probably be on a large scale, but would be formed by earthen banks across the valleys in which the streams run. These embankments would be, probably, at intervals in the course of a stream, and farms of moderate size would be more or less dependent on each reservoir.

The paper refers to the question of artesian wells, and it is pointed out that these would be disappointing as sources of supply for irrigation, although they might give a valuable supply of water for cattle on the great grassy plains which abound in the temperate regions.

The paper concludes with certain recommendations concerning investigations which appear necessary before colonisation, either by Europeans in the temperate tracts, or by natives of India in the less temperate areas, can be established with good hope of success. Irrigation would, no doubt, be most valuable; but as yet it has not been proved that crops cannot be successfully cultivated by the rainfall alone, if the cultivation is conducted with a due consideration of the local seasons.

3. *Survey of the Fresh-water Lakes of the British Isles.*
By T. N. JOHNSTON, *M.B., C.M.*

The paper gave a summary of what had been done towards carrying out the scheme announced at the Glasgow meeting of the Association for the survey of the fresh-water lakes of the United Kingdom under the superintendence of Sir John Murray. The lochs of the Rannoch district have all been surveyed, and the work is being gradually advanced northwards through Argyllshire, Inverness-shire, Ross-shire, and Sutherland, in which last county the staff employed on the work were at the time of the reading of the paper engaged in surveying the lochs of the Assynt district. Up to the beginning of September 1902 nearly 100 lochs had been surveyed. Besides taking soundings the members of the survey carried on biological and physical investigations in all the lochs. One of the most interesting observations hitherto made was that of the occurrence of seiches on several of the Scottish lakes. The phenomenon was observed by the author of this paper first on Loch Treig, the first known observation of such an occurrence in Scotland. Subsequently it was observed on several other lakes.

4. *The Jordan Valley.* *By* Professor WILLIAM LIBBEY, *Sc.D.*

The paper discusses some of the geological features of the valley, and the connection between the Dead Sea and the Gulf of Akabah.

There seems to be less evidence of a fault with a subsidence upon its eastern side than was supposed. There was, however, undoubtedly a rift valley or fracture, which was widened at a later period. This valley extended from the foot of Mount Hermon southward.

The evidence of ice action on the southern slopes of Mount Hermon is very marked. This is not found upon the surface, where abrasion has probably removed all traces of it, but in places where the rocks have been covered up by moraines, which latter have but recently been removed.

From the northern end of this valley, throughout its whole extent, its structure is strongly suggestive of that of a fjord where the ice has been absent for a very long period.

A possible conception of the valley and its mode of formation might be that some time at the close of the cretaceous period this rift was formed. It was then widened and deepened by ice action, at least as far south as the Sea of Galilee, if not throughout its whole length.

After this the surrounding region was submerged by a depression of its surface, due to lateral pressure from the westward. It was at this time that the immense deposits of sandstone took place which were laid down in the valley nearly as far north as the Sea of Galilee. The thickness of these sedimentary deposits was about 4,000 feet, and their character varied, dependent upon the source of the material which was laid down.

Subsequent to this a gradual elevation of the layers took place, and as long as the supply of water was abundant the stream cut its way down through the sandstone, leaving fringe-like remnants on both sides of the valley, as well as an underlying mass in its bed. The protected lateral bays or alcoves on the sides of the main rift were found to be occupied by such deposits. The Lisan Peninsula might be regarded as a more resistant remnant than usual in the bed of the valley.

After this process had continued for a period long enough to bring about the removal of some 3,000 feet of this deposit, a change in the conditions took place, and one of three things happened, possibly all three:—

1. The glacier disappeared.
2. The water-supply failed to a considerable extent.
3. The rate of elevation increased.

Then the course of the water over the top of this sandstone ‘plug’ first became sluggish and finally stopped, thus breaking the connection with the ocean.

From this time onward, while elevation to the extent of about 1,000 feet took place, erosion upon this sandstone bed took place in two directions—northward and southward—and a harder layer than usual, about the middle of the trough connecting the Dead Sea and the Gulf of Akabah, eventually became the turning-point of the waters in both directions.

This process is also illustrated in a similar remnant lying between the Jebel Usdem and the western face of the main limestone walls of the valley throughout the whole length of that peculiar range.

5. *Petra.* *By* Professor WILLIAM LIBBEY, *Sc.D.*

Petra is located in one of the larger bays or alcove valleys on the eastern side of the valley connecting the Dead Sea with the Gulf of Akabah. The depth of this bay inland must have been about seven miles.

The immense amount of sandstone here laid down was apparently affected by surface erosion only, as it was withdrawn from the active scouring action which was going on in the main valley to the westward. It therefore rose or was lifted up some 3,000 feet above that valley, while the limestone cliffs, its eastern shore line, still towered above it to the height of 3,000 feet more.

As you look down upon it from the old Roman road on the top of these cliffs, it appears like a tumbled sea of sandstone waves, so rough is its surface.

There is one channel, however, which has persisted in cutting its way down through this sandstone mass from the lower edge of the limestone plateau to a central depression with precipitous walls. This was the entrance to the location of the famous ancient city.

The stream occupying this cleft, after passing through the central valley, plunges headlong down a splendid canyon, through several thousand feet of sandstone to the valley of the Arabah, which lies some five or six miles distant. This latter portion of the Sik is all but impassable; the upper portion, leading to the site of the city, is easily traversed, in fact it once had a Roman road leading along its winding bottom.

The position of this 'Rock City' forms a marked contrast to other 'strong places' of Moab, which were usually walled hilltops. It required no less military genius to grasp the elements of its strength and use them as a defence. The sturdy Roman was probably the only invader who became its foreign master, and he succeeded more by craft than by the force of arms.

The strange juxtaposition of its temples and amphitheatre to the thousands of tombs which surrounded them produces a curious impression upon the mind. It seems odd to us that their games and joyous festivals should be celebrated in full view of the solemn porticoes of the last resting-places of their ancestors.

The splendid structures carved in the walls of rock which surrounded their city have resisted the 'tooth of time' very remarkably for 1,500 years, considering the soft material in which they are found. The city proper, with the exception of a single temple and part of an arch of triumph, have literally crumbled into dust.

Views of canyon entrance to the city, the chief Latin monuments, the still older Moabite 'high places,' as well as some pictures taken from Aaron's tomb on Mount Hor, were shown.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Papers were read :—

1. *World-shaking Earthquakes in relation to Volcanic Eruptions in the West Indies. By* JOHN MILNE, *F.R.S.*

Observation shows that every year about fifty earthquakes occur, each of which disturbs the world throughout its mass. Between January 1, 1899, and January 1, 1902, the number of world-shaking earthquakes which have been recorded and the regions from which they originated were as follows:—

		No. of Earthquakes
A.	West and South of Alaska	25
B.	West of Central America	14
C.	West of the Antilles	16
D.	West of the Andes	12
E.	East of North Japan	29
F.	South and East of Java	41
G.	North of Mauritius	17
H.	East side of the North Atlantic	22
I.	West side of the North Atlantic	3
J.	North Atlantic	3
K.	Balkan, Caucasian, Himalyan Regions	14
		196

The disturbances originating from districts H, I, J, and the Balkan portion of K, although they were recorded in the Isle of Wight, were comparatively small and are therefore not considered in the above yearly average. All these origins lie on the flanks or near the base of the steepest flexures on the earth's surface. With the exception of K they are submarine, and their boundary ridges are, for the most part, lined with volcanic peaks.

For the greater number of these ridges there is geological and, not infrequently, historical evidence to show that the most recent movements have been those of elevation, and periods of volcanic activity accompany elevation rather than subsidence.

When a world-shaking earthquake originates on land, dislocations many miles in length have been formed, on the two sides of which large areas have been relatively raised or lowered. In 1891, in Central Japan, a fault was formed having a length exceeding forty miles and a 'throw,' as shown on the surface, of 10 or 20 feet.

Mr. R. D. Oldham shows that the Assam earthquake of 1897 was probably due to a movement of 10,000 square miles of country along a thrust-plane through a distance of 16 feet.

The Cutch earthquake of 1819 resulted in a subsidence of 2,000 square miles of country and the elevation of a ridge fifty miles in length.

When the origins have been suboceanic, soundings have shown that vast depressions have been formed, whilst coast lines have been raised or lowered. In 1822 about 100,000 square miles along the coast of Chile were permanently lifted about 3 feet.

Observations like these indicate that large earthquakes originating in the furrows described are accompanied by a deepening of the same and an elevation of the flanking ridges. This elevation may relieve constraint at volcanic foci with the result that volcanoes, particularly those which have been sealed for many years, may suddenly burst into activity, a sequence of events well illustrated by the volcanic history of the Antilles. In these islands there were eruptions in the years 1692, 1718, 1766, 1797, 1802, 1812, 1836, 1851, and lastly, the most terrible of all, in the present year. All of them seem to have closely followed huge adjustments of the Hayti-Jamaican fold, or those in the neighbouring folds on the American continent.

The 10,000 small earthquakes which are recorded in the world every year have not any sensible relationship to volcanic activity.

2. *Preliminary Note on the Windings of the Evenlode.*
By Dr. A. J. Herbertson.

3. *Geographical Plant-groups in the Irish Flora.*
By R. Lloyd Praeger, *B.E.*

Ireland may be roughly likened to a saucer, of which the central depression consists of a plain of Carboniferous limestone, the rim of a discontinuous series of mountain-groups formed of non-calcareous rocks. Much smaller than Great Britain, it displays less diversity of climate as well as of surface, and consequently less diversity of flora.

The application of Watson's well-known 'types of distribution' to Ireland is productive of some interesting results, and shows a considerable diversity of range in the same groups of plants in Great Britain and in Ireland.

The 'English' plants of Watson reach in Ireland their maximum on the East coast, in Dublin, Wicklow, and Wexford, and are also remarkably abundant in Clare. Watson's 'Scottish' plants show a more uniform range in Ireland. They attain their maximum in the northern maritime counties. Thence they spread down the West coast in considerable abundance as far as the Shannon mouth, while on the East coast they decrease rapidly south of Down. Watson's 'Highland' plants are found chiefly in the west. They attain their maximum on the comparatively low hills of Donegal and West Galway, and are only sparingly represented on the higher mountains in the east, such as those of Down, Wicklow, and Tipperary. Watson's 'Germanic' group is practically non-existent in Ireland; the fragments which have reached that country have a quite irregular distribution, with a maximum in Clare. The 'Atlantic' plants have a more definite distribution in Ireland, ranging round the coast and showing an increase southward.

A careful analysis of the distribution of plants in Ireland reveals the existence of several fairly well defined types. There is a marked tendency to a 'Central' or 'Marginal' distribution, the result of the configuration of the country, the Central group being largely composed of lowland, calcicole, and aquatic or paludal species; the Marginal of calcifuge, upland, and dry-soil plants. Well-marked northern and southern, eastern and western groups also exist, the boundaries between them consisting of lines running not exactly east and west, or north and south, but rather north-north-eastward from Cork to Londonderry and east-north-eastward from Galway Bay to Dundalk Bay. For these six types of distribution the author proposes the names Central, Marginal, Ultonian, Mumonian, Lagenian, Connacian, the last four being taken from the old names of the four provinces of Ireland, in each of which one of the groups attains its maximum. The characters of each plant-group, and its relations to the climatological and physiographic features of the country were pointed out.

4. *On some Features of the Cork River-valleys. By* J. PORTER.

The author discusses the special features which are presented by the drainage system of Cork county, including the abrupt change of course which transfers each of the trunk rivers of the east from one longitudinal strath to a more southerly one, and the more or less straight and meridional character of the cross-courses. The paper connects the abrupt changes from one main strath to another with glacial interference; while it assigns to faulting and the rapid flow of the pre-Glacial streams conjointly the determining part in bringing about the meridional character of the cross-courses and many of the tributary glens.

5. *The Peat-bogs of Ireland. By* Professor T. JOHNSON, *D.Sc.*

The author gave an account, illustrated by a large map prepared by the Intelligence and Statistical Branch of the recently created Department of Agriculture and Technical Instruction for Ireland, of the distribution of the bogs of Ireland, which cover 1,861 square miles, or nearly 6 per cent. of the surface, chiefly in counties Donegal, Mayo, and Galway, and in the central plain, as the Bog of Allen. Their average depth is 25 feet. An account was given of the character of the different layers of a bog as seen in a vertical section, and an explanation suggested of the origin of a bog-slide. Specimens of the bog-flora, of the different kinds of peat, and of the economic products derivable from turf or peat, lent from the Botanical Collections of the National Museum in Dublin, were exhibited.

6. *The Island of Sakhalin and its Inhabitants. By* C. H. HAWES, *B.A.*

The Siberian island of Sakhalin has hitherto remained unexplored by Englishmen. Having overcome the difficulties of approach, I was suspected of being a military spy on landing.

The remoteness of the island is emphasised by the fact that communications are absolutely cut off during half the winter, and for the other half are dependent on native dog-sledges driven across the frozen Strait of Tartary.

A brief historical sketch of the discovery of the island tells of the first known expedition, made by the Japanese in 1613, followed by the Dutch captain, Vries, in 1643. La Pérouse visited Sakhalin in 1787, an English captain, Broughton, in 1796, and Kruzenstern during the years 1803–1806; but none of these succeeded in navigating the Strait, or as it was then called, the Gulf, of Tartary. Finally, in 1849, the long-thought peninsula was demonstrated to be an island by Captain Nevelsky. Native legends are still current which tell of a neck of land connecting the mainland, and these find possible support in the fauna and flora.

A backbone of mountains, culminating in Mount Itschara, nearly 5,000 feet high, stretches throughout the length of the island, which is little short of 600 miles. Except for clearings around isolated Russian penal-settlements the surface is mainly covered with dense forests, the home of the bear, reindeer, wolf, fox, sable, &c.; and though swampy regions exist, the general character is better described by the Siberian term 'taiga' than 'tundra.'

Geologically the island belongs to the Tertiary period, argillaceous sandstone and calcareous schist being much in evidence, while coal is abundant on the west coast. No traces of recent volcanic action are yet to hand.

The middle of the island forms the watershed of two rivers, each with a course of about 300 miles, one flowing north and the other south.

The climatic conditions comprise extreme cold in winter with heavy falls of snow, but the annual rainfall is less than that of England. The prevailing exaggerated notions of constant fog need to be dispelled.

The inhabitants of the island consist of (*a*) Native tribes, and (*b*) Russians.

(*a*) *Natives.*—Traces are found of extinct dwarf pit-dwellers. The present inhabitants comprise five different tribes or races. (i) *Ainus*, in the south of the island; a dying race. (ii) *Gilaks*, a semi-Mongol, semi-Tungus tribe. (iii) *Orotchons*, a more pronounced Tungus tribe. (iv) *Yakuts*, with only thirteen representatives. (v) *Tunguses*, the great hunters of the island.

(*b*) *Russians.*—Sakhalin is a Russian penal-settlement, with a white population consisting of convicts, ex-convicts, and officials. There are comparatively few political exiles, but a large percentage of murderers. Thousands of the latter are at large under surveillance; and many escape from the prisons into the forests, rendering travelling unsafe.

TUESDAY, SEPTEMBER 16.

The following Papers and Report were read:—

1. *The Motives of Antarctic Exploration.*
By Hugh Robert Mill, *D.Sc., LL.D.*

The motives which underlie the efforts to solve the problem of the Antarctic regions and the nature of that problem have changed from age to age.

With the ancient Greeks it was a mere academic speculation as to whether there were Antarctic regions or not, in other words a discussion as to the figure of the Earth.

After Aristotle's demonstration that the Earth is a globe the question came to be whether the Antarctic regions were accessible, and the theory of zones of climate answered it in the negative, as it was believed that life in the torrid zone was impossible.

In the early middle ages belief in Antipodes, either of the west or of the south, was stigmatised as a pagan error, and many prominent upholders of the belief in the existence of Antarctic regions were excommunicated.

The necessity of finding a sea route to India for commercial purposes led eventually to the crossing of the tropics and the circumnavigation of Africa and America.

Belief in the existence of a great southern continent extending even to the tropics, derived from the beliefs of Ptolemy and stimulated by discoveries of islands on the verge of the unknown, led to all the southward exploration of the sixteenth, seventeenth, and eighteenth centuries, culminating in the second voyage of Captain Cook, who proved that the Antarctic continent, if it existed, nowhere penetrated far into the temperate zone.

Commercial motives, actuated by Cook's discoveries of fur seals and oil seals in South Georgia, ensured active Antarctic exploration by sealers from 1780 to 1839, the most successful in advancing knowledge being Palmer, Weddell, Biscoe, and Balleny.

The desire to give security to sailing-ships running a great-circle course to Australia, India, and China by improving knowledge of magnetic variation helped to produce the great expedition of Sir James Clark Ross in 1839–43 and stimulated those of Wilkes and Dumont D'Urville about the same time.

Subsequent attempts at commercial exploration have failed, and the only motive now acting is the pursuit of pure science for its own sake; and this has sent out the 'Belgica' expedition, the British, German, and Swedish expeditions now in the field, and will send out Mr. Bruce's expedition from Scotland.

2. *The Scottish National Antarctic Expedition.* *By* W. S. BRUCE.

The object of the Scottish National Antarctic Expedition is to specialise in oceanography and meteorology; but biology, geology, and magnetism will also be actively pursued. Its sphere of operations will be the south of the South Atlantic Ocean, between the tracks of the Swedish and German expeditions. The base of the expedition will be the Falkland Islands, and from there a course will be steered south-east to the Sandwich group, and thence south into the Weddell Sea. During the summer an attempt will be made to reach as far south as possible without incurring the risk of the ship becoming frozen into the ice in the winter, for it is intended, by keeping the ship free during that season, to continue the scientific work up to and outside of the limit of the polar ice. A wintering party, composed of several of the scientific staff, will also be left in the south if funds permit. The expedition will be absent for a period of two years.

The ship is a rebuilt Norwegian whaler, and has been named the 'Scotia.' She is a barque-rigged auxiliary screw steamer of about 400 tons. She carries a crew of twenty-five and a scientific staff of eight. Mr. W. S. Bruce, the leader, has appointed Captain Thomas Robertson, of Peterhead, to command the ship.

3. *The Islet of Rockall.* *By* Rev. W. SPOTSWOOD GREEN, *F.R.G.S.*

In June 1896 the author had the rare opportunity of conducting a scientific expedition in the ss. 'Granuaile,' placed by the Congested Districts Board of Ireland at the disposal of the Royal Irish Academy for the purpose, to Rockall, the most outlying speck of the British Islands. It stands on a bank to the N.W. of Ireland, cut off from the British plateau by a great abyss of 1,600 fathoms, covered with the globigerina ooze of the ocean depths, into which that plateau suddenly descends, from a depth of 300 fathoms, the edge of the plateau being found to be composed, wherever the author has trawled, chiefly of erratic subangular blocks or boulders.

The rock consists of a single tooth of granitoid rock, of such special character that it bears the name of 'rockalite.' Close by the main rock, which is only 70 feet high and about 75 yards in circumference, the Haslewood Rock appears above water at half tide, while two miles to the N.E. a rocky ridge known as Hellen's Reef comes within 6 feet of the surface, and constitutes the greatest danger of the locality. Within 20 yards of Rockall we got 30 fathoms of water, and the soundings at a short distance from any of the rocks is 70 fathoms. The 100-fathom line follows the general outline of the whole bank. So far as soundings go Rockall is more connected with the Arctic area than with the British Islands.

From its situation the fauna of the islet and bank might be expected to differ from that of the British seas, and some interesting specimens of animal life not belonging to the British fauna were, in fact, discovered in trawling on the bank. The Great Shearwater was seen on the islet, but the nesting-place of this bird was sought in vain

In the sixteenth century, one of Martin Frobisher's ships, a 'Busse,' when returning from the Arctic discovered an island of several miles in extent about the position of Rockall. Rockall and its reefs are not referred to in charts or writings of that period. Whether this 'Land of Busse' could have been Rockall or not, prior to its last stage of denudation, has been fully discussed by Mr. Miller Christy; he inclines to the negative.

The old charts also indicate an islet called Hybrassil, about 300 miles to the south of Rockall, and it seems a strange coincidence that this also should occupy a site approximately the same as the Porcupine Bank, discovered within the last century, and rising as an isolated patch of shoal-water on the very utmost limit of the British plateau.

A number of photographs illustrating fairly well the appearance of this lonely isle were shown.

4. *Charnwood Forest, a Buried Triassic Landscape.*

By Professor W. W. WATTS, *F.G.S.*

5. *Second Report on Terrestrial Surface Waves and Wave-like Surfaces.*

See Reports, p. 285.

6. *Note on Captain Sverdrup's North Polar Expedition.*

By Sir CLEMENTS MARKHAM, *K.C.B.*, *F.R.S.*

7. *With Lieutenant Peary in Greenland.*

By Professor WILLIAM LIBBEY, *Sc.D.*

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

PRESIDENT OF THE SECTION—EDWIN CANNAN, M.A., LL.D.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

IF it happened every year that the President of this Section undertook to justify his own existence, I am afraid the Section would become weary. But my four distinguished predecessors have all been drawn from the Civil Service, and though each of us may have doubts about particular branches of the Civil Service, we are mostly willing to allow that as a whole it is at least a necessary evil, so that we do not get apologies from the Presidents who, so to speak, represent the practice of political economy. I hope, therefore, that you will bear with me if I offer some reasons for thinking that the teaching and study of the theory of economics is not, as many people seem to suppose, a wholly unnecessary evil, but, on the contrary, a thing of very great practical utility.

I do not mean to argue that a knowledge of economic theory will enable a man to conduct his private business with success. Doubtless many of the particular subjects of study which come under the head of economics are useful in the conduct of business, but I doubt if economic theory itself is. It does not indeed in any way disable a man from successful conduct of business; I have never met a competent economist who was in a position of pecuniary embarrassment, and many good economists have died wealthy. But economic theory does not tell a man the exact moment to leave off the production of one thing and begin that of another; it does not tell him the precise moment when prices have reached the bottom or the top. It is, perhaps, rather likely to make him expect the inevitable to arrive far sooner than it actually does, and to make him underrate, not the foresight, but the want of foresight of the rest of the world.

The practical usefulness of economic theory is not in private business but in politics, and I for one regret the disappearance of the old-name 'political economy,' in which that truth was recognised.

One of the commonest complaints of the time is that there is no text-book of economics which commands any really wide approval, and you may therefore, I think, fairly ask me to explain what I mean by the teaching and study of economic theory before I undertake to prove its practical usefulness in the discussion of legislative and administrative measures. I will therefore endeavour to sketch as shortly as possible the course of instruction which the modern teacher of economic theory, if unhampered by too close adherence to traditional standards, puts before those who come to him for instruction.

The first, or almost the first, thing he will do is to try to open the eyes of his pupils to the wonderful way in which the people of the whole civilised world now co-operate in the production of wealth. He may perhaps read them Adam Smith's famous description of the making of the labourer's coat, a description which required three generations and three great writers to elaborate in the form in which we know it. Or he will ask them to consider the daily feeding of London. There are, he will point out, six millions of people in and about London, so closely packed together that they cannot grow anything for their own consumption, and yet every morning their food arrives with unfailing regularity, so that all but an infinitesimal fraction of them would be extremely surprised if they did not find their breakfast ready to hand. To prepare it they use coal which has been dug from great depths hundreds of miles away in the Midlands or Durham; in consuming it they eat and drink products which have come from Wiltshire, Jamaica, Dakota, India, or China, with no more thought than an infant consuming its mother's milk. It is clear that there is in existence some machinery, some organisation for production which, in spite of occasional failures here and there, does its work on the whole with extraordinary success. It is easy to be pessimistic, especially when the weather is damp, and we are apt to concentrate our attention, and to endeavour to make others concentrate their attention, on this or that defect, and to forget that the system is not made up of defects, but on the whole works very well. Imagine the report of a really outside observer. In all civilised planets, I have no doubt, there must be an institution more or less resembling the British Association. An economist in Mars, let us say, has been favoured with a glimpse of this island through a new mammoth telescope of sufficient power to let him see us walking about, and he is reporting to Section F what he saw. Will he say that he saw a confused scramble for the scanty natural products of the earth? That most people were obviously in a state of starvation? That few had clothes? And that scarcely any were housed? No, truly; he will be much more likely to report that he saw a wonderfully orderly population, going to and from its work with amazing regularity, without a sign of compulsion or unwillingness; that it appeared to be fed and clothed and housed in a way extraordinarily creditable on the whole to some mysterious organisation, the nature of which he could only guess at.

Having endeavoured to make his pupils recognise that we are organised, and that the organisation works, the teacher will go on to show how it works: why things that are wanted are produced in the places where they can be easiest produced and taken to the places where it is most convenient to consume them; why people go to live in large numbers in spots where it is desirable they should work, and leave great areas sparsely inhabited; why more people are brought up to follow an occupation when the desire for its products increases, and fewer when it decreases; why if the harvest is short the consumption is economised so as to spread it over the year; and so on. The answer to all these questions is of course 'self-interest' or 'the hope of gain.' Durham coal, Wiltshire milk, Danish butter, Jamaica sugar, Dakota wheat, and China tea go to London because it pays to send them there. People congregate in London or Belfast because it pays them to work there. More do not come, because it would not pay them. Young people leave agriculture and go to towns to make agricultural implements or bicycles because it pays. The consumption of grain is economised and spread over the year because it pays to hold the stock. If people with one accord left off doing what paid we should all be dead in two months.

The reasons why it pays to do the right thing—to do nearly what an omniscient and omnipotent benevolent Inca would order to be done—are to be looked for in the laws of value. This used to be regarded as a somewhat arid subject, but the discussions of recent years, especially the contribution made by Jevons and the Austrian school, have fertilised it. Long ago, economists pointed out how the much-abused corn-dealer who held out for a higher price saved the people from starvation; and we now, thanks to the theory of final utility, not only know that it is a fact, but also why it is a fact, that value rises with the extent and urgency of demand, so that when a thing is much wanted much is offered to those who produce it, or are ready to part with it, and consequently its production is stimulated or its consumption economised, as need be.

This will naturally lead to the question of distribution—the question, that is, why much of the produce falls to the share of one individual and little to that of another;

why, in a word, some are rich and others poor. The teacher will here explain that the share of each person depends on the amount and value of his contribution to production, whether that contribution be labour or the use of property. He will show how this system of distribution is essential to the existing system of production, where no man is compelled to work or to allow his property to be used by others, and where every man has legal freedom to choose his own occupation and the uses to which he will put his property. He will beware of claiming for it that it is just in the sense in which justice is understood in the nurseries where jam is given when the children are good. There is, he will explain, no claim on behalf of the system that it rewards moral excellence, but only that it rewards economic service. There is no claim that economic service is meritorious. Whether a man can and does perform valuable economic service does not by any means depend entirely on his own volition. His valuable property may have come to him by bequest or inheritance; his incapacity to do any but the least valuable work may be the result of conditions over which he has had no control. The system exists not because it is just, or to reward merit, but because it is inextricably mixed up with the system of production. It has one great evil—its inequality. Moralists and statesmen have long seen the evils of great inequality of wealth, and now, thanks to modern discoveries in economic theory, the economist is able to explain that it is wasteful, that it makes a given amount of produce less useful, because each successive increment of expenditure yields, as a rule, less enjoyment to the spender. The teacher will go on to show how this organisation of production and distribution is made possible by the order enforced by government, and how, in various ways, government supplements or modifies it; but I shall not enlarge upon this part of the teaching of economics, as its practical usefulness is obvious. My theme is the usefulness of the other part, the explanation of the organisation of production and distribution in so far as it depends on separate property, free labour, and the consequent action of self-interest.

In the first place, I maintain that the widespread dissemination of such teaching would help to do away with a vast amount of most disastrous obstruction of necessary and desirable changes. Take, for example, the obstruction offered to changes in international trade. Of course every conceivable argument has been used by different writers in wholly different circumstances for obstructing the co-operation of mankind in production, as soon as it oversteps a national boundary. But what is the real support of this kind of obstruction? Obviously the fact that certain producers, or owners of certain means of production, are damaged by an increase in the importation of a particular article. Their loss, their suffering, if their loss is severe enough to deserve that name, appeals to popular compassion, and their request for 'protection' is easily granted, the new trade is nipped in the bud, and things are forced to remain in their accustomed channels. The same principle is not applied as between county and county or between province and province, simply because there is then visible to everyone an opposing interest, the interest of the new producers, within the hallowed pale of the national boundary. Adam Smith tells us that when the great roads into London were improved, some of the landlords in the home counties protested on the ground that the competition of the more distant counties would reduce their rent. The home counties did not get the protection they wanted, because it was obviously to the interest of the more distant counties that they should not have it. These two interests being balanced, the interest of the consumer, London, turned the scale. So it usually happens that beneficial changes in internal trade are allowed to take their course without obstruction because the votes of two sets of producers counteract each other, and the consumer's interest settles the question. But in international trade one of the two sets of producers is outside the country: it consists of hated foreigners, the fact that it will benefit is an argument against rather than for the threatened change in trade, and the consumers therefore feel it patriotic to sacrifice their own interest and vote for protection. But if they were properly instructed in economic theory they would see at once that such magnanimity is entirely misplaced. They would see that it would cut away all international trade, since, if there were no fallacy involved in it, the stoppage of each import taken separately would benefit home producers and damage foreign producers. Even if some of the imported commodities could not be produced at all at home, substitutes, more or less efficient, could be produced and give all the more employment. Having acquired some notion of the advantages of co-operation and the territorial division of labour, the consumers would regard this as a *reductio ad absurdum*, and after thinking a little further they would soon see that, after all, there is another set of producers, actual or potential, within the country who will gain—namely, the producers, present or future, who will supply the articles which are to go abroad in exchange for the new import. They will see that what they are asked to do is not to maintain the amount of national production, but merely to prevent a change in its character which will be accompanied by an increase in its amount.

Take another example of Chinese obstructiveness to desirable change. As great cities grow, it becomes convenient that their centres should be devoted to offices, warehouses, and shops, and that people who work in these places, and still more their families, should live in the outskirts. I do not know that anyone has denied this. Certainly the great majority are willing to admit it. At one time it is believed that a quarter of a million people lived in the square mile comprised within the City of London; no one supposes that would be convenient now. There is no reason to suppose that further change in the same direction will not be desirable in the future. Yet, incredible as it will appear to future generations, public opinion, the House of Commons, the London County Council, and some town councils think, or at any rate act as if they thought, that the process has now gone far enough and ought to be stopped; as if the state of things reached about the year 1891 was to be permanent, to last for ever and ever. Private owners are indeed still allowed to pull down dwelling-houses and erect shops and offices, but they are abused for doing so, and their liberty is at least threatened. But if a new railway or a new street is made—in all probability with the intention of increasing the accessibility of the centre from the suburbs—if even a new London Board School is built, and houses inhabited by persons who have less than a certain income are pulled down in any of these processes, it is required by law or parliamentary resolution that other houses for these people must be built in the neighbourhood. So it comes about that there are in quarters of London most unsuitable for the purpose enormous and repulsive barrack dwellings, the sites of which are devoted *in secula seculorum* to the housing of the working classes; while the immense cost of devoting them to this instead of to their proper purpose is debited to the cost of improving the facilities for locomotion or to education, and is defrayed principally by the rates on London property, which chiefly consists of houses, and to some extent by the higher charges on the railways consequent on the restriction of facilities for extension. Fifty pounds a head is the average loss involved to the rates of London on every man, woman, and child for whom these dwellings are provided. Such is the wisdom of practical men uninformed by instruction in economic theory.

This palpable absurdity could never have been perpetrated if the general working of the economic organisation had been understood. In that case it would have been seen at once that the extrusion of over 200,000 inhabitants from the City of London in the past, which is admitted to have been desirable, was effected by the quiet operation of the laws of value. It would have been seen that as it became desirable to turn the City to other purposes, the ground in the City became too valuable to use as bedrooms and as living-rooms for mothers and children, and this increase of value drove out the 200,000 inhabitants. It would have been seen that the change had not come to an end, and no responsible body would have dreamt of putting themselves in opposition to it by buying sites and writing them down to 2 per cent. of their actual value in order that they might be tied up for ever and ever to be the homes of a certain number of persons with less than a certain income. If some unusually dense individual who had failed after many attempts to pass his examination in economic theory had proposed the policy which has been adopted, he would have been asked two questions: first, 'What peculiar sanctity is there about the position occupied in the closing years of the nineteenth century? Why should this be stereotyped for all time? Why should not the position at the end of the seventeenth century have been maintained? Why should we not endeavour to restore the working classes to their old home in the City, and remove the Bank of England to Tooting?' Secondly, 'Whom do you imagine you will benefit by the policy you propose?'

It is difficult to conceive of any answer to the first question. To the second the reply of the dunce would of course be that he thought the policy proposed would benefit the people housed on these expensive sites. This answer would at once be condemned as unsatisfactory. To build houses on land worth 100,000*l.*, and let them to the first-comers of respectable antecedents at rents which would pay if the land were worth 2,000*l.*, would be a very stupid sort of almsgiving if these respectable first-comers actually got the difference between the interest on the 100,000*l.* and the 2,000*l.* But no one supposes that they do get this difference or any considerable part of it. The difference is almost entirely pure loss to the community. The chief immediate effects of the policy are, first, to retain in the centre the men, women, and children who inhabit the dwellings; secondly, to retain other workers who perform various offices for these inhabitants; and thirdly, to ensure a supply of labour for factories which would otherwise (to the advantage of everyone concerned) be driven into the country by the pressure of the high wages necessary to bring workmen to the centre or to pay their house rent if they lived there.

So much for the utility of economic theory in preventing obstruction of desirable changes. My second claim on its behalf is that it serves to hinder the adoption of specious but illusory projects. This, I think, may be illustrated by examples closely connected with those which we have already considered under the head of obstruction.

The people who are most anxious to obstruct changes in the channels of trade which are coming about of themselves because they are profitable, are often extremely anxious to promote changes which will not come about of themselves because they are not profitable. For this end one of their most favourite devices at present is a State or municipal subsidy to locomotion or transport between particular points. So we have shipping subsidies, free grants to light railways, the construction of unprofitable telegraph lines by the post office, and the advocacy, at any rate, of the construction of unprofitable tramways by municipalities. The practical man, uninstructed in economic theory, feels uneasy about such projects because he does not see where he is to stop, and he feels obscurely that a universal subsidisation would mean ruin. But he does not see why he should not go a little way, and he goes sufficiently far to involve a loss quite worth considering. A knowledge of economic theory would come to his assistance by showing him that, as a rule, the most profitable enterprises are those which it is most desirable to undertake first, and that the subsidisation of the less profitable does not create new enterprises, but merely changes the order from the more desirable to the less desirable. I suppose that if in 1830 Parliament had offered a sufficient subsidy a railway might have been at once made and worked from Fort William to Fort Augustus, to the great satisfaction of the inhabitants of Fort Augustus and the intermediate places. But it is obvious that it was more desirable, in the interests of the whole community, that the railway from Fort William to Fort Augustus should wait for seventy years, and that the railway from Manchester to Liverpool, and many others, should be made first.

Then, too, we find people who are not quite so stupid as to think the working classes should always remain in the places where they were at the end of the nineteenth century, alleging that the way to cure overcrowding is for local authorities to enter the building trade in a general way, and build houses inside or outside their districts, wherever it seems most convenient. To the mind uninstructed in economic theory it seems obvious that the larger amount of housing there is the less overcrowding there will be, and that the more housing local authorities provide the more housing there will be. Economic theory, with its explanation of the general working of the organisation of production, suggests two objections. First, an addition to the housing in any locality will not be effectual in diminishing overcrowding, in so far as it attracts new inhabitants to the spot; a policy which assumes that the comparative plentifulness of houses is not a factor in the determination of the enormous and perpetual migration of people from place to place which is indicated in the tables of birthplaces and births and deaths in the census, is doomed to failure. Secondly, economic theory suggests the reflection that the mere fact of a local authority building some houses will not cause the whole number to be greater, if for every house built by the local authority one less is built by private enterprise, and that this is very likely to happen. Houses have been built by private enterprise in the past, and in these houses nearly the whole population is at present housed. I have seen an enthusiast for municipal housing stand in the empty streets of a town late at night, when every soul in the town was evidently housed, and say, in a tone of conviction, 'Private enterprise has failed.' In that town four small houses had been built by municipal enterprise and more than ten thousand by private enterprise, and private enterprise was adding hundreds every year, while the housing committee of the corporation was meeting once a year to re-elect its chairman. Is it likely that private enterprise will build as much when it is competed with or supplemented by—the term does not matter—municipal enterprise? Why should it? If the municipality turned baker, would the private bakers continue to bake as much bread? Is not the attempt to stop overcrowding by inducing local authorities to build houses exactly the same thing and just as absurd as it would be to attempt to cure under-feeding by opening municipal butchers' and bakers' shops?

In the long run, I admit, experience teaches. Protection has fallen once in this country, and I have little doubt that it will fall again if it becomes considerable. The policy of obstructing the removal of dwellings from the centre of a great city already excites opposition in the London County Council, though unanimity still reigns in those last homes of extinct superstitions, the Houses of Parliament. Chancellors of the Exchequer and finance committees may be trusted to offer a stout resistance, on what they call financial grounds, to any really great development of the system of subsidies. There is hope even that the municipal building policy may be checked by the laborious inquiries which show by statistics what everyone knows, that the poor are ill-fed and ill-clothed as well as ill-housed, and therefore lead people to consider how the poor may be made more able to pay for houses, among other things, instead of simply how houses may be built in the absence of an effective demand for them. But I claim that, in matters such as these, a more widespread appreciation of economic theory, and the quickened intelligence which that would produce, would save us much painful experience, many expensive experiments, and an enormous mass of tedious investigation.

Thirdly and, at any rate on the present occasion, lastly, I claim that the teaching and study of economic theory has great practical utility in promoting peace and good will between classes and nations.

Between classes within the same nation the peacemaking influence of economic theory lies chiefly in the fact that it tends to get rid of that stupid cry for 'rights' and 'justice' which causes and exacerbates industrial and commercial quarrels. When demand for some commodity falls, or supply from some new quarter arises, and profits and wages fall, the workers cry out that they are being unjustly treated, because they have the unfounded belief that reward is or ought to be proportional to moral merit, and they are not conscious of any diminution of their moral merit. They demand a living wage or a minimum wage and employment for all who happen to have been hitherto employed in the trade, rend the air with complaints, and get subscriptions from a compassionate but ill-informed public. We cannot, of course, expect people who suffer by them to regard even the most beneficial operations of the economic organisation with enthusiasm or even satisfaction. It would be absurd to do so. But all the same, it is true that a wider apprehension of the fact that it is only by raising and lowering the advantages offered by different employments that production is at present regulated so as to meet demand would not only diminish the dissatisfaction, but also, which is more important, diminish the actual suffering by causing transitions to be less obstinately resisted. The present fashion of deploring rapid changes of trade and dwelling-place is a most unfortunate one; the ordinary forms of labour do not, as a matter of fact, require such specialised ability that there should be much difficulty in changing from one to another; and surely it is much better for a man to work at several different things at different places in the course of his life than to stick for ever in the same place, surrounded by the same objects, going through the same monotonous round of duties. Anything which will weaken the present obstructive sentiment and lead people to regard the necessity of a change of employment or residence as a temporary inconvenience rather than a cruel injustice is to be warmly welcomed.

It is not, however, only the poor and the industrious who would be taught by a greater knowledge of economic theory not to kick against very necessary pricks. The rich, both industrious and idle, would be taught to be far more tolerant than they are of attempts to diminish inequality of wealth by reducing the wealth of the rich as well as increasing that of the poor. The economist may be a little annoyed with the workman who insists that he ought to have thirty shillings a week for producing something worth fifteen shillings, or five shillings, or nothing at all, but he can only have hearty contempt for the millionaire who holds up his hands in holy horror and murmurs 'confiscation,' 'robbery,' 'eighth commandment,' when it is proposed to relieve him of a fraction of a farthing in the pound in order to bring up destitute orphans to an occupation in which they may earn twenty-five shillings a week. The sanguine teacher of economic theory has hopes of making even such a man see that he has his wealth, not because Moses brought it down from Sinai, or because of his own super-eminent virtue, but simply because it happens to be convenient, at any rate for the present, for society to allow him to hold it, whether he obtained it by inheritance or otherwise. In other words, that private property exists for the sake of production, not for the sake of the particular kind of distribution which it causes. Some, I know, say that the rich are so few that it does not much matter whether they acquiesce in the measure meted to them or not; but that is not the teaching of history, and I think you will agree with me that for the progress of the whole community it is, in practice, quite as important to secure the acquiescence of the rich as of the poor.

In regard to international relations, the first business of the teacher of economic theory is to tear to pieces and trample upon the misleading military metaphors which have been applied by sciolists to the peaceful exchange of commodities. We hear much, for example, in these days of 'England's commercial supremacy,' and of other nations 'challenging' it, and how it is our duty to 'repel the attack,' and so on. The economist asks what is 'commercial supremacy?' and there is no answer. No one knows what it means, least of all those who talk most about it. Is it selling goods dear? Is it selling them cheap? Is it selling a large quantity of goods in proportion to the area of the country? or in proportion to its population? or absolutely, without any reference to its area or population? It seems to be a wonderful muddle of all these various and often contradictory ideas rolled into one. Yet what a pile of international jealousy and ill-feeling rests on that and equally meaningless phrases! The teacher of economic theory analyses or attempts to analyse these phrases, and they disappear, and with them go the jealousies suggested by them.

When misleading metaphors and fallacies are dismissed, we are left with the facts that foreign trade—the trade of an area under one government with areas under other governments—is merely an incident of the division of labour, and that its magnitude and increase are no measures of the wealth and prosperity of the country, but merely of the extent to which the country finds it convenient to exchange commodities of its own growth or manufacture for commodities produced elsewhere. If the city of York were made independent, and registered its imports and exports, they would come out far larger per head of population than those of the United Kingdom or any other great country. Should we be justified in concluding York to be far richer than any great country? If means were discovered of doubling the present produce of arable land with no increase of labour, much less corn would be imported into Great Britain and less of other goods would be exported to pay for it; the foreign trade of the country would consequently be diminished, but would the people be any less prosperous? What jealousies, heart-burnings, and unfounded terrors leading to hatred would be extinguished if only these elementary facts were generally understood !

To anyone who has once grasped the main drift of economic theory, it will be plain that the economic ideal is not for the nation any more than for the family that it should buy and sell the largest possible quantity of goods. The true statesman desires for his countrymen, just as the sensible parent desires for his children, that they should do the best paid work of the world. This ideal is not to be obtained by wars of tariffs, still less by that much greater abomination, real war, with all its degrading accompaniments, but by health, strength and skill, honesty, energy, and intelligence.

The following Papers were read :—

1. *The Localisation of Industry.* *By* Rev. W. Cunningham, *D.D.*

The economic principles which account for the concentration of industry so that it may be conducted on a large scale are very familiar. It is worth while to discuss, so far as possible—I. The conditions which have led to the concentration of a given trade in one particular locality ; and II. The probabilities of a counteracting tendency in favour of decentralisation.

I. Concentration is partly due to physical conditions, as in the case of coal-mining, or of favourable circumstances for growing some crop ; but the transport of *material* is so easy that industry is less bound than was formerly the case to the area where it can be obtained. Facilities for *water power* have had much to do with localisation in the past, though good *opportunities for trade* have been even more important. These last accounted for the extraordinary growth of London at the expense of other towns in the seventeenth century. When a trade has been consciously planted in any district, it has been due to *conditions of life* rather than merely to the *conveniences for the industry*. Some aliens (Flemings in fourteenth century) have been attracted to England by *political* and others (Huguenots) by *religious* conditions ; while the terms which a particular *organiser* could offer have accounted for the development of the trade under his supervision, as in the case of Crommelin and the linen trade. Physical conditions will always be an element, but the business capacity of some capitalist seems to be the main factor in the successful planting or developing of trade in a particular locality.

II. The process of decentralisation may be observed in recent years in connection with the trade of London and other ports respectively. It showed itself in the diffusion and increased prosperity of the clothing trade in the eighteenth century, when the large employer had little, if any, economic advantage over the domestic workman. The conditions of life which can be offered in garden cities may tend in favour of decentralisation ; and though the survival of the village artisan seems unlikely, there is a possibility of organising industrial employments in rural districts. Still though decentralisation may help to cure over-crowding it is unlikely to revive the old type of village life.

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2. *The Influence of Economic History on Economic Theory.*
By Arch. B. Clark, *M.A.*

The battle of the schools which about twenty years ago absorbed the attention of economists, threatened to seriously impede the advance of economic science, and did for a time accentuate the prevailing distrust of the teaching of economists, is now a matter of history ; and it is possible to estimate with some approach to impartiality the abiding influence of the controversy on economic theory.

It is common knowledge that the historical school has failed to make good the claim of its extreme representatives to transform or revolutionise economic science by substituting, for the abstract statical laws reached by the hypothetical deductive method of the Ricardian school, historical investigation, yielding at most dynamical laws or generalisations as to the course of economic development. The extravagance of the claim provoked an equal extravagance of repudiation. But it is now generally admitted that there is room for both the economic historian and the economic theorist; and their labours have become mutually helpful in proportion as each has confined himself more strictly to his proper sphere.

There can be no doubt that economics, in common with modern science generally, has gained immensely from the application of the historical method. It is not merely that the study of economic history has furnished abundant material by means of which the economic theorist can illustrate or test his deductive conclusions. It has led, in the interpretation of theory itself, to a really effective recognition by economists of the truth that in most cases their conclusions or laws have merely a *hypothetical* and in others only a *relative* validity. In this way it has done much to remove the basis of that popular misconception of, and antipathy to, political economy for which the teaching of Ricardo and his early disciples was in some degree responsible.

The influence of the historical conception in this direction is seen if we consider that among the leading defects of the teaching of the early Ricardians were—(1) Their employment of faulty abstractions which, as in the case of capital, gave rise to (*a*) an intensely materialistic view of industrial progress. As a consequence of this, (*b*) in their treatment of distribution the force of attention was misdirected, and the influence of efficiency on wages was ignored. Human nature was treated as a constant, and labour as a mere commodity, of which the price was inevitably determined, under the influence of free competition, by the laws of demand and supply. Thus (*c*) it was tacitly assumed that the mechanical theory of exchange exhausted the problem of distribution. This was associated with another defect, namely, (2) their treatment of these faulty abstractions as if they were concrete realities, *e.g.* the 'economic man.' From this, again, naturally followed (3) their incautious advocacy of *laisser faire*, as exemplified especially in their opposition to the early Factory Acts.

On all these points the historical conception has profoundly influenced the teaching of the latest representatives of the classical English school. But the tendency, elsewhere prominent, on the part of the leaders of the historical school to confuse ethical and economic considerations, and to justify a great extension of the sphere of governmental action, has had little influence in this country, where the application of the historical and comparative method is generally held to have decidedly strengthened the presumption in favour of freedom of contract, and against governmental action, as the general rule.

3. *The Position of Economics and the Applied Sciences in a proposed University Training of Persons intended for a Commercial Life.*

By W. R. SCOTT, *M.A.*, *D.Phil.*, *Litt.D.*

'Higher Commercial Education' is intended to provide a suitable training for persons who aim at discharging the duties of responsible positions in business. Such education should embody the principles of subjects taught: therefore it falls within the sphere of the university. The relative importance of principles of knowledge as opposed to applications of principles constitutes the distinction between the university and the technical college.

In Germany, about twenty years ago, higher commercial education was understood as the study of science and its application to industries. But a training in applied science alone is not a complete commercial education, because such training ignores the claims of economics.

In England the tendency is towards the opposite extreme of proposing the extension of the study of economics and political science as a higher commercial education. The following are examples of recent developments in this direction:

(1) The proposed curriculum for Honours in Economics at Cambridge, as

suggested by Professor Marshall, the chief subjects being History, Economics, and Political Science.

(2) The existing Honours Degree in Economic Science at the Scottish Universities.

(3) A proposed post-graduate school at Oxford in Economics and cognate subjects.

(4) The new degrees of B.Sc. and D.Sc. (in Commerce, &c.) at London University, the subjects for the ordinary B.Sc. being Economics, History, Public Finance, and either Accountancy or a legal subject.

(5) The Edinburgh scheme of granting the M.A. degree (with certain modifications) in 'commercial' subjects.

While these schemes are satisfactory so far as they go, they cannot be accepted as supplying a *complete* education of the future business man by the university. For instance, they give no teaching that would be helpful towards the understanding of the processes of manufactures, therefore they need to be supplemented by courses in applied sciences. Such teaching (*e.g.*, economics and applied science) has the advantages of both the English and German systems. Two schemes endeavour to effect this union—that of the Birmingham Faculty of Commerce (adapted for a university which works on the three-term system with a B.A. degree); and a scheme proposed for universities, such as those of Scotland, with a long session.

(1) *The Birmingham Scheme* offers the degree of Bachelor of Commerce after a three years' course. The following are the subjects of examination at the end of the third year: A.—Six papers in *all* of the following: 1, Commerce; 2, Modern Languages; 3, Accounting; 4, Commercial Law; 5, Transport. B.—Six papers *chosen from* the following: 1, Technique of Trade; 2, Money, Credit, &c.; 3, Methods of Statistics; 4, Factory Hygiene; 5, (i) Physics; (ii) Chemistry; (iii) Engineering; (iv) Metallurgy; (v) Economic Geology; (vi) Electro-technics; (vii) Brewing; (viii) Mining.

(2) *A Scheme adapted to the Scottish Universities*, proposing the degree of B.Sc. (in Economics and Applied Science) after two courses of lectures and two examinations in each of the following subjects selected by the student: First examination in three subjects on the M.A. standard. Final examination in three or more subjects on an honours standard (one subject at least to be taken from Group ii). *Subjects*: Group i.—1, Commercial Law; 2, International Law; 3, Modern History; 4, Political Science. Group ii.—5, Agriculture; 6, Economic Botany; 7, Geology, &c.; 8, Engineering; 9, Political Economy; 10, Public Finance; 11, Pure Economics, Banking, &c.; 12, Technological Chemistry; 13, Technical Zoology; 14, Transport.

The advantages of the last proposal are that in every case the student will enter on the applied part of his course after having acquired a sufficient acquaintance with the principles of his subject. The flexibility of the scheme enables subjects to be grouped so as to answer the needs of most businesses. The extension of the influence of the universities to include practical interests would be valuable both to them and the students of the proposed curriculum.

FRIDAY, SEPTEMBER 12.

The following Papers were read:—

1. *Trusts: from the Point of View of Economical Theory.*
By Professor W. Graham, *M.A.*

The principal object of the paper is to attempt to estimate the effect of a general Trust system on the chief economic categories—namely, production, prices, profits (including interest), and wages.

In it I have endeavoured to show: (1) That production under a Trust system would be largely increased on account of certain economies and greater returns. (2) That the question of wages, so difficult even under the present system, half competitive, half of combination, would not be more difficult on the whole under a Trust system; and that self-interest would prevent a reduction of wages below former levels, from the increasingly clear perception of intelligent managers that good labour is worth high wages, and inferior labour often 'dear at the price,' though low; that accordingly wages might, *ceteris paribus*, be as high as under the existing order, though Trade Unions would occupy a less strong position than at present to enforce their desires by a strike, without being entirely helpless; that the employment of the working classes would probably be more steady, though their sense of independence might not be so strong. (3) That as regards prices, while the Trusts would have power of fixing them at discretion, and in some cases would be much tempted to raise them beyond what competition-prices would have been, that nevertheless their sense of self-interest, if not of pecuniary interest, would be a check on the most important cases; and that while there would probably be a difference between competitively determined and monopoly determined prices, unfavourable to certain classes of consumers, it would be less than some enemies of Trusts apprehend, owing in part to the elements of monopoly at work at present in determining prices. (4) That profits and the rate of profits as understood by Mill, and consequently dividends or profits *minus* wages of manager and insurance, would be raised, and raised more because manager's salary is a fixed amount; but that some of the owners of capital would not be benefited by the rise on account of the shares taken by promoters and underwriters.

These general theoretical conclusions are afterwards compared with the results of some of the more notable American experiments in Trusts, as gathered from American economists, with a view to test their soundness and applicability to real cases that may arise, especially in countries under a system of Protection, which give a much fuller scope to the evolution of Trusts.

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2. *Shipping Combinations.*

By BENEDICT WILLIAM GINSBURG, *M.A., LL.D.*

The subject divides itself into two parts, the first is historical, namely tracing the combinations which have already been effected, and the causes which have contributed to their happening. Most of those of which we have had experience have been consolidations of existing interests and absorptions of minor services which great companies have judged likely to serve as useful feeders to their main lines. The Atlantic combination now before the public is of a different character. It is an application of the American trust system to the exploitation of the sea-carrying trade. It involves of necessity a considerable dilution of the capital of the business it absorbs. Its success, from a shareholder's point of view, must therefore involve either a raising of freights to make a due return on the larger capitalisation, or a considerable economy in operation to make the net profit sufficient to give the proposed return. The first of these two alternatives would seem to involve the setting up of a monopoly, since the Protectionist policy of the United States under which the great body of their trusts have been built up will not assist the promomotion of this enterprise. The 'through bill of lading,' of which so much has been said in this connection, is not a new institution, and cannot for several reasons be pressed indefinitely. In the first place its success would depend on practical control of the railways to the eastward. In the second, American pride in the restoration of the influence of the Stars and Stripes on the sea, if not of its actual reappearance on ocean steamers, will not induce Americans to submit to large increases in the payments for carriage, since eventually in the open markets for produce the American shippers would feel the effects of such increase. A continued and appreciable increase in freights would depend on the establishment of a monopoly, since outside tonnage can be attracted to paying stations, though outside factories cannot be brought into competition with land businesses. The success of the combine must therefore depend on the promised large economies. How far the promise that two and a half millions sterling can be saved each year by centralisation of control is subject to the comments that, though the expenses may be cut down the incitement to individual effort is continuously lessened, whilst the beneficial effect of laying up redundant vessels in slack times is minimised by the fact that the large items of interest on cost, depreciation, and insurance run on against the laid-up ships, whilst the competitors of the combine—who do not contribute to the charges in respect of these ships—benefit, equally with their owners, by their removal from the competition. The considerations which make it doubtful how far the shareholders in the absorbed companies will benefit by what is taking place do not apply to Belfast's interest in the matter. She will undoubtedly benefit by the certainty of regular demands for the produce of her yards. Nor is it likely at present that a change of flag will take place. But whilst the promised economies in working may prove illusory or transitory, the additions to the capital on which any return to shareholders must be made are certain, large, and abiding.

3. *Municipal Trading.* *By* HON. ROBERT P. PORTER.

The broadest objections to municipal trading would seem to be six in number:—The injurious effect upon the work strictly within the municipal sphere of operation; the fact that in giving attention to trading operations the 'unproductive' work is almost certain to be neglected; the tendency to discourage improvement or development; the engendering of ill-feeling which is sure to arise when the taxpayer finds himself obliged to help defray the cost of competing with himself; the difficulty in adjusting the burden of a trading undertaking on the right shoulders, and such an equitable regulation of the charge as will not put a burden on those who derive no benefit; the impossibility of drawing a line as to which industries shall be taken up by municipalities, and which shall be left to individual enterprise.

In the early part of the last century the various State Governments of the United States entered into financial partnership with the promoters of canals; and later, when steam railways were introduced, States and cities, and towns and counties, were alike appealed to for assistance in building railways. Nor was the appeal unheeded, for in the forties and fifties an epidemic, very similar to the present fever for municipal trading in England, literally swept over the country, and ended in bankruptcy and ruin, not only of cities and towns, but of important States. Bonds issued by State and local authorities for the promotion of railways went in default.

These and kindred experiences taught us the useful lesson that there was a limit to State and municipal credit. The taxpayers of those times, who saw their property practically confiscated to pay for enterprises which should have been left to individual endeavour or private speculators, invented a device known to us as 'the debt-limit clause'; and this clause, in some form or other, has been inserted in nearly every State Constitution drawn and adopted since those days of financial disaster and destruction of State and local credit.

Partially because of the debt limitation, and partially because private enterprise has been allowed a freer headway in such undertakings as the supply of gas, electric lighting, tramways, and telephones, we find in the United States no city owning and operating its own tramways and street railways, probably less than half a dozen manufacturing gas, a very few engaged in supplying electric light, and, I think, not one in the telephone business.

Municipal trading is rapidly increasing municipal debt in England, and serious complaints may be heard on all sides in consequence of the increase of local taxation. The answer is that the debt is 'productive,' and that the profits of these industrial undertakings will be used to reduce the taxes. Sir Henry Fowler's admirable statistical classification of indebtedness shows that the so-called 'productive' debt is only about half of 1 per cent. beyond the danger line; that is, the dividend or profit from this debt averages half of 1 per cent. If, in consequence of the anxiety in financial circles at the steady increase of local debt, the rate of interest should rise ⅛ per cent. on all local securities, what would become of the 'productive' debt? Assuming that the trading debt represents one-third of the total local debt, a rise of a ¼ per cent. would extinguish the 'productive' properties of these loans, and, in a sense, throw them on the rates.

Without suggesting any remedy for municipal trading, an alternative plan would be the leasing system, which, when the contracts are wisely drawn, secures the revenue for the city treasury and good cheap service for the public. On the other hand, it shifts the financial risk from the ratepayers' shoulders. This, with some form of debt limitation, will gradually modify existing conditions, especially if backed by a strong public opinion in opposition to further use of public funds in this manner. In spite of the activity of municipalities in England, private capital has not been entirely beaten in the race; while I observe in certain quarters it holds its own admirably in competition with tax-exploited industry. Even the capital invested in private company electrical undertakings is increasing, and this in spite of almost insurmountable obstacles. It is a case for gradual readjustment, not violent change. With the facts fully understood, the people will by degrees curtail these unwise and dangerous economic experiments, and bring cities back to the sphere of work which is strictly their own.

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4. *Municipal Policy and State Control.* *By* PERCY ASHLEY, *B.A.*

1. The problem of municipalisation has ceased to be argued on theoretical grounds; it has become a question of practical expediency. In this it resembles the larger controversy about national economic policy, and it is possible that the growing belief in the necessity of State intervention in economic matters, in order to promote national efficiency, is due in part to the development of municipalisation.

The municipalities have realised that for them competition has rarely been effectual, and that in the interests of city administration it is advisable for them to intervene. The tendency has been therefore for public services to pass rapidly from the uncontrolled to the controlled state, and then to municipalisation. This is the case not only in Great Britain, but elsewhere; for example, in Prussia, where it is the work of an anti-Socialist bureaucracy.

2. The theoretical line of demarcation between services which may or may not be municipalised is then abandoned; a practical distinction must be sought. Each case must be considered separately, with reference to two questions: (1) Is it likely to promote municipal efficiency? (2) Can it be properly conducted by the municipality which proposes to undertake the service?

In regard to (1), municipalisation will, *primâ facie*, promote efficiency when the particular public service concerns (*a*) public health, which is the real reason for the existence of modern local authorities, and (*b*) the control of the streets.

In regard to (2), there are two important matters to be considered. The first is the financial aspect of the proposal. The problem of local debt is much discussed at present, but it must be remembered that nearly half of it has been incurred for remunerative services (lighting, water-supply, &c.); and of the remainder much has been incurred compulsorily, and some part (*e.g.* expenditure on sewers) is indirectly remunerative. But in regard to any particular proposal, account should be taken of the amount of debt to be incurred, the relation of the total debt of the town to its assets and rateable value, the arrangements for payment of interest and contributions to depreciation and sinking funds. It is also necessary to decide if a service is to be classed as remunerative or unremunerative; for the first a *fee* should be charged rather than a *price*, for the second a charge on the rates may be allowed. It is possible that housing will have to be placed in the second class. The other point to be considered in regard to (2) is the administrative ability of the local authority concerned, and its real intention to make use of the powers sought (so as to avoid the recent scandals in the matter of the supply of electricity).

3. Can we devise a system of control which will deal adequately with all these

considerations? All our present methods defective. A suggestion for a new system.

There should be a standing committee, consisting of members of the two Houses of Parliament, together with an extra-Parliamentary panel of persons nominated by the County Councils Association, the Association of Municipal Councils, and the Local Government Board. To this committee all private Bills containing proposals involving municipalisation should go; it would (*a*) decide all questions of new powers, and all points submitted by sub-committees, in full meeting; (*b*) deal with the details of each separate application by sub-committees. It should be required to have before it in all cases (1) a report from the authority (Local Government Board or other) which controls finance on the financial part of the proposal and the financial position of the local authority applying for power, and (2) a report on the general question of the proposal from any Government Department concerned (Home Office, Board of Trade, Local Government Board).

As general instructions to the committee the following principles should be laid down: The general character and quality of the local authority which makes the application must be considered in any grant. Each municipal enterprise must be classed by the committee as remunerative or unremunerative, and in the former case the principle of a fee rather than a price should be enforced whenever possible. The accounts of each separate undertaking must be kept as fully and distinctly as those of a similar enterprise conducted by an ordinary firm; they should be subject, not merely to a State audit, but to an accountant's audit, paying special regard to depreciation and sinking funds. Finally, the committee should fix a reasonable time within which the local authority shall make use of its powers or (unless it can show reasonable cause for delay) have them revoked.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Papers were read:—

1. *A Sketch of the Linen Industry of Ireland.*

By Sir R. LLOYD PATTERSON, *D.L.*, *F.L.S.*

The capital engaged in the business is estimated at about twelve millions sterling, and the number of operatives directly employed at about seventy thousand, earning some 3,000,000*l*. annually in wages.

The paper refers to the probable origin of the trade, and the source whence it may first have come to Ireland; and mentions instances of Irish linen being alluded to in history in the ninth, tenth, and twelfth centuries.

Passing over the intermediate period, the writer arrives at the year 1699, when a French Huguenot refugee named Crommelin settled in Ulster, and introduced many improvements in the methods of flax preparation and manufacture previously prevailing.

The Linen Board was established in 1711.

Flax-spinning was done by hand till 1828, and linen-weaving by hand till 1847, in which years the mill-spinning of yarn and the power-loom began to supersede the former methods. The rise and progress of these new processes is described, reference being made to the simultaneous decline of the formerly important industry of cotton-spinning in Belfast and neighbourhood.

The rise of and subsequent fluctuations in flax-growing in the country and the concurrent fluctuations in prices of home-grown and other flaxes are alluded to; as are also the exports of yarns and linens—the latter a gradually diminishing quantity of late years.

The importation of flax yarns into Ireland is increasing, while their export is diminishing; and this change has affected the direction of trade. The effect of the American war and consequent high prices of cotton on the linen trade, and the reaction following that period of inflation, are traced; and an attempt is made to account for the recent decline in the linen industry of the world, in which decline Ireland suffers much less than her British and Continental competitors.

A new fabric, the Kneipp linen mesh underwear, is affording a fresh outlet for yarn; but still more variety is wanted in linen manufactures.

The legitimate manufacturer is injured by the undue length and over-laxity of credits.

Wages and the housing of the operatives are discussed.

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2. *A British Zollverein, or Preferential Tariffs within the British Empire.*

By His Honour Judge SHAW, *K.C.*

There are two main proposals for establishing closer commercial relations between the various parts of the Empire. One is a British Zollverein, or a General Customs Union, which shall embrace every part of the Empire. The other is the establishment of a system of tariffs by which the United Kingdom shall give preferential advantages to the products of the Colonies and other parts of the Empire, whilst the other parts of the Empire shall give similar advantages to the products of the United Kingdom and of each other.

It is very often assumed that these two proposals are similar in tendency and effect. This is a total mistake. The two proposals are opposite to, and almost contradictory of, each other. A British Customs Union would be a measure of Free Trade, abolishing all Customs barriers and restrictions upon commerce within the Empire. Preferential tariffs, on the other hand, are essentially *Protective* in their tendency, and imply the existence of those barriers within the Empire which a Customs Union would abolish. The two proposals, therefore, must be kept quite distinct in our minds, and dealt with on entirely different lines.

I. A British Zollverein would mean absolute freedom of trade within the whole British Empire, a common Customs barrier as against all the rest of the world, and no Customs or duties to be payable on transit from one part of the Empire to the other. It is useless to consider whether this would be *desirable* until we have first ascertained that it is *practicable*. It is at present wholly impracticable, for the following reasons:—

1. There is no common central authority within the Empire to regulate the imposition of Customs duties, their collection, and their division among the various parts of the Empire.

2. A common Customs would necessitate also a common Excise within the Empire.

3. It would mean a complete break-up and rearrangement of the whole fiscal system both of the United Kingdom and of the other parts of the Empire. Tea from India, for example, could not be taxed in the United Kingdom, and manufactures from Great Britain could not be taxed in the Colonies.

4. The Colonies are not prepared for Free Trade within the Empire, and have decidedly rejected every proposal in that direction.

II. The proposal for preferential tariffs takes two forms:—

Firstly, there is the proposal to impose a uniform tax of 5 or 10 per cent. on all foreign imports into any part of the British Empire.

To this proposal there are three decisive objections:—

1. As Sir R. Giffen has shown, an enormously large proportion of this tax

would be paid by the manufacturers and consumers of the United Kingdom, and a very insignificant part by the other parts of the Empire.

2. So far as the United Kingdom is concerned, the tax would fall almost exclusively upon imports of food and raw materials of manufacture, the very articles which it is most vital to British industry to procure from the cheapest and most convenient markets; whilst in the other parts of the Empire it would fall almost exclusively upon manufactures the importation of which it is the policy of the Colonies to discourage.

3. The Colonies and other parts of the Empire would gain enormously by a tax which raised the price of food and raw materials in the markets of the United Kingdom, whilst the United Kingdom would gain comparatively little by any tax which raised the price of its manufactures in the Colonies.

Secondly, there is the proposal embodied in the resolution of the New Zealand Government of December 1901, in favour of the Colonies giving a rebate of duties on British-manufactured goods carried on British-owned ships, and the Mother Country giving a rebate of duties on colonial products now taxable.

1. There can be no objection to the Colonies showing their good will to the Mother Country by reducing their tariffs in favour of the products of the Mother Country; but what can the Mother Country do in return?

2. Preferential tariffs therefore, if there is to be reciprocity, necessarily involve the Mother Country putting on taxes on her imports of food and raw materials for the sake of remitting them in favour of her Colonies.

3. This would involve a tremendous disturbance in our manufacturing system and our foreign trade, and a rise of price all round in our food and raw materials.

4. It would also involve us in difficulties with those foreign nations which concede to us by treaty the most-favoured-nation treatment for our exports.

5. The effect of the rebate of duties already conceded to us by the Dominion of Canada does not encourage us to expect any great results from such rebates elsewhere.

6. Our whole commercial and fiscal system is founded upon principles of Free Trade; that of the Colonies is founded on Protection. The proposal under consideration practically comes to this: that instead of the Mother Country, as in old times, dictating a commercial policy to the Colonies, the Colonies should dictate a commercial policy to the Mother Country.

3. *The Effects on Ireland of the Adoption of Free Trade by the United Kingdom.* *By* BENJAMIN ALLEN, *M.A.*

The principles of Free Trade have passed through many changes in public, and even in scientific estimation. The refusal of the civilised world to abandon the Protectional policy is among the causes which have led to this change, for the prediction that the world would soon follow England's example has not been fulfilled. Another cause is the state of Ireland. This country shows a rapidly decreasing population, while the progress of England in population and wealth during the last half-century has been enormous. So far as Ireland is concerned there is ample proof that Free Trade has had some very important results. At the time of the Union the population was a little more than five millions; in forty years it rose to more than eight millions, and these eight millions of people lived in a considerable degree of comfort, as they understood it. Ireland was at one time a wheat-growing country. Its native Parliament encouraged this industry by bounties on exports and inland carriage. One result was a rapid increase in population. In the thirty years preceding the Union and in the forty-six years from the Union to the repeal of the Corn Laws, Ireland was the granary of England. It now imports grain of all kinds. This revolution in the economic condition of the country was the result of the adoption of Free Trade. Irish wheat ceased to have the monopoly of the English market. Mr. Lecky states that the chief cause of depopulation of Ireland was the conversion of arable into pasture land, and that this was entailed by Free Trade. The emigration statistics show how rapidly this depopulation took place. From 1851 to 1860 the emigrants from Ireland numbered 1,163,418; 1861-70, 849,836; 1871-80, 623,933; 1881-90, 770,706; 1891-1900, 433,526; a total from 1851 to 1900 of 3,841,419, consisting of 2,013,344 males and 1,838,075 females. The large majority of these emigrants were young, strong, and enterprising—just the class which it is most desirable to keep at home. Thus in 1900, 82·3 per cent. were between the ages of 15 and 35. It would be difficult to estimate the national loss caused by this vast emigration, which is still going on, though not quite so rapidly. Not only has wheat almost ceased to be grown, but the acreage under flax, formerly a most profitable crop, has greatly diminished, owing to the free importation of flax from Belgium and other countries. It may be said that this is good for the linen trade, but that is doubtful. The trade is not as prosperous as it was, and it depends for its existence almost on the steady supply of imported flax.

The loss inflicted on Ireland by the destruction of a large part of its cereal and flax-growing industry has not been compensated by gain in other directions.

The revenue from the export of cattle has not increased to an extent at all corresponding to the loss from the causes mentioned. In England, though agriculture is depressed, manufactures have flourished. It has not been so in Ireland. Her agriculture has been ruined, and her manufactures, except in Belfast, have not increased.

The suggestion that a remedy should be sought for in a moderate measure of Protection is not outrageous. Reflection on our national weakness due to the dependence of the people for their food-supplies on imports from foreign countries has stimulated the tendency to look towards Protection, and that tendency ought also to be increased by a consideration of the state of Ireland. In Ireland the work of the rent-fixing courts, and the creation by the Land Purchase Acts of a peasant proprietary on a large scale, would enable those who are actually engaged in agriculture to enjoy the prosperity which a moderate measure of Protection would afford.

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4. *The Instability of Prices in India before* 1861.

By Professor T. Morison, *M.A.*

It has been asserted that prices have been more stable in India than in Europe. The object of this paper is to show, by the publication of price-lists for the earlier years of the nineteenth century, that the tendency of prices in India has been from irregularity to stability; that the prices before 1861 fluctuated violently and irregularly; and that as means of communication improved, and as India came under the influence of Western trade, prices became comparatively stable.

Table I. gives the prices of wheat at eight different centres in Rohilkhand and the Doab—that is to say, in a comparatively small area of the N.W. Provinces of India—from 1803 to 1860. Table II. gives the available prices for barley, and Table III. for bajra. The price of wheat in Bareilly is represented by a price-curve from 1805 to 1899. This curve shows that before 1861 the price of wheat fluctuated violently, on five several occasions the difference of price within the space of one year being over 20 seers; the lowest price recorded in the century is 73 seers to the rupee (in 1815), and five years later (1820) the price had risen (temporarily) to 18 seers to the rupee. The fluctuations in the price of the coarser grains, the staple food of the people, are even more extravagant; there seems to have been no such thing as a normal price for barley or bajra. The extreme limits of variation for barley are 120 seers to the rupee in 1829, and 28 seers (ten years later) in 1839; for the decade 1809-1818 the prices are 51, 57, 110, 95, 53, 96, 113, 87, 66, and 34 seers to the rupee. But, great as are these fluctuations, they do not in all probability represent the full extent of the actual variations, for these prices are the average prices of the year; and we know, from the difference between harvest prices and annual prices, that the fluctuations within the twelvemonth were hardly less surprising.

By reference to the charts it will be seen that after 1861 prices grew steadily more stable, though with a marked upward tendency, due to the inflation of the rupee currency. In the last thirty years the price of wheat oscillates between a maximum of 9 seers and a minimum of 25 seers to the rupee, and barley between the limits of 12 seers and 38 seers. This comparative stability is due to improvement in the means of communication. In the earlier half of the nineteenth century every town and village constituted an isolated and independent market; nowadays, owing to metalled roads and railways, there is practically one price for grain all over India.

It may be objected that the figures I have given are only for cereal crops, which are particularly exposed to the vicissitudes of climate, and that I have not shown that all prices were liable to these fluctuations. In a country so wholly agricultural as India, the prices of grain are almost the only prices available. I have, however, been able to find a record of the price of one article of general consumption which is not affected by the causes which produce famine prices in cereals. Table IV. gives the price of *ghi* in Pilibhit from 1813 to 1854, which is represented on a price-curve that reveals very considerable fluctuations. This is the more remarkable because *ghi* belongs to that class of commodities the supply of which cannot be very largely increased or decreased in a short space of time; the fluctuation in price is therefore probably due in part to a fluctuation in demand, and thus illustrates the contention that before 1860 the tendency of silver prices in India was to fluctuate, and not, as is sometimes contended, to be stable.

5. *The Depopulation of Ireland: its Causes and Economic Results.*

By J. H. EDGAR, *M.A.*

The decrease in the population of Ireland still continues, and is attracting serious attention. The population in 1901 was 4,458,775. In 1800 it was five millions, and in 1846 over eight and a half millions. The great increase in the first half of the century was the result of the extreme subdivision of the soil, consequent on the rise of prices during the French war. There was no standard of comfort to act as a restraining influence on the increase of numbers. The country was in danger of becoming a pauper warren. Landlords commenced to save the situation by consolidating the holdings, and were aided in this end by the famine of 1846, which struck down over 700,000. The famine and the consolidating policy were the chief factors in the phenomenal emigration of the next few years; reference to census table to show results. From the year 1854 to the year 1875 the consolidation of the small holdings and the change from tillage to pasture were the chief causes of the falling numbers. Sketch of the Landed Estate Court, its object and ultimate results—increased severity of evictions, and the consequent changes in the population.

In Ireland there are no great industries to check emigration. Halt at 1875 to show by reference to quick changes in agricultural prosperity the importance of agriculture on the numbers of the people.

Increased decline in decade 1881–91 and its causes. General insecurity in land tenure—mighty influence on emigration. Ireland's loss can only be explained by local causes. Influence of taxation.

Consequences—benefit to emigrants. To residue—wages high. This is now itself a cause of decline of tillage. Poverty less. Reference to Savings Bank returns. More cattle and land per head of population, but decline in horses; gratifying increase in poultry. Joint-stock banks show steady and great progress. Many explanations of above. Unsatisfactory increase of unproductive classes. The country has got rid of weight of paupers of famine time, and the emigration ought to be stayed. Any further loss must be mischievous.

6. *The Population of England and Wales during the Eighteenth Century.*
By Professor E. C. K. GONNER, *M.A.*

In considering the population for the eighteenth century, that is, for the century preceding the first census, there are two matters to consider:

(1) The particular value of a knowledge of the population for that century. *E.g.*, it would enable us to answer three important questions:—(*a*) Effect on the country at large of Walpole's peaceful policy in the early decades. (*b*) Date when manufacturing began to be the dominant interest in England. (*c*) Date when changes in methods of agricultural ownership and cultivation began to affect the population of rural districts.

(2) Material for estimating population in the eighteenth century. These in the main are two: (*a*) house-tax returns—

i. These employed by contemporaries and formed the subject of certain violent controversies, especially in the latter part of the century.

ii. But these statistics have certain peculiar defects, mainly by reason of evasion.

(*b*) Returns made of baptisms, burials, and marriages at earlier dates. Parishes in England summarised in Prefaces to Census Returns, 1831 and 1841. With regard to these the estimate formed on them tend to over-estimate the population in the eighteenth century.

The general conclusion arrived at is that the increase of population during the eighteenth century was much greater than is generally thought.

TUESDAY, SEPTEMBER 16.

The following Report and Papers were read:—

1. *Report on the Economic Effect of Legislation Regulating Women's Labour.*—See Reports, p. 286.

2. *History of the Regulation of Home Work*, 1864–1901.
By Miss B. L. HUTCHINS.

Factory legislation had been a subject of violent controversy in the first half of the nineteenth century. During the sixth and seventh decades the opposition lost much of its bitterness, and public opinion gradually inclined to accept the principle of State control. The Children's Employment Commission of 1862–66 recommended the extension of regulation to children employed by their parents in their own homes. In 1867 a Workshops Act was passed which was intended to place the hours and conditions of women and children's labour under a uniform system of regulation, not only in workshops, but in the smallest workplaces where 'any handicraft' was 'exercised for gain.' This Act was ill-drafted, administratively weak, and consequently ineffective.

From 1874 onwards there was a renewal of opposition to Factory legislation, especially in regard to restrictions on women's work. The Factory and Workshops Consolidation Act of 1878 exempted domestic workshops and women's workshops from most of the provisions applicable to workshops generally. The evidence given before the Lords' Committee on the Sweating System in 1889–90, showed the effect of these exemptions, and in the subsequent period there has been a new movement in favour of legislative control. Amending Acts have been passed, aiming (among other things) at levelling up the provisions for health and safety in workshops and work-rooms. Among suggestions for further strengthening the law, which have been made by Mr. Charles Booth, Mrs. Sidney Webb, and others, are the following:—

(1) Compulsory registration of all workshops.

(2) The landlord, jointly with the employer, to be made responsible for the sanitary condition of work-places.

(3) Extension of Clause 107 of the Act of 1901 to all industries. This clause requires that in any class of work specified by special order of the Secretary of State, the occupier of a factory or workshop, or contractor employed by him, shall keep lists of the out-workers employed, such lists to be sent twice a year to the district council, and to the factory inspector, when required.

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3. *The Administration of the Factory and Workshops Acts by Local Sanitary Authorities. By* Miss A. Harrison.

Domestic workshops have been more or less under legislative control for nearly forty years, and during this time various experiments have been made with regard to the administration of the Factory and Workshops Act in workshops. These experiments are particularly interesting to students of Local Government, as they present problems in connection with the relation between central and local authorities.

Domestic industries were for a long time considered to be beyond the province of legislative control, partly because it was thought that it would be impossible to enforce the regulations in small scattered workshops, and in the homes of industrial workers. The Children's Employment Commissioners of 1864 pointed out that this objection could no longer be raised, as the local inspectors appointed under the Public Health Act needed only to be armed with specific powers to enforce the Factory Acts in workshops.

In 1867 the experiment was made of placing the Workshops' Regulation Act in the hands of the local sanitary authorities. With a few notable exceptions the local authorities either ignored the Act or refused to administer it.

The experiment failed for the following reasons:—

(1) No form of control was exercised by the central authority over the local bodies to compel them to undertake the duties laid upon them.

(2) Inadequate powers were given to the officers of the local authorities.

(3) The indefinite nature of the regulations made the Act a most difficult one to administer.

In 1871 the administration of the Workshops' Regulation Act was handed over to the Home Office, and for the next twenty years the inspection of workshops under the Factory Acts was carried on entirely by the inspectors of factories. Owing to the large number of scattered domestic and other workshops the factory inspectors met with great difficulty in their attempts to discover unnotified workshops, and many of those in which the worst conditions prevailed escaped inspection altogether.

In 1891, when women's workshops were brought under the same sanitary regulations as ordinary workshops, and when the law with regard to the sanitary condition of workshops generally was made more stringent, the local authorities were made responsible for the sanitary condition of all workshops, and the duty of discovering unnotified workshops was placed upon them. With a few exceptions, the local authorities have merely acted upon complaints, and have failed to take any initiative with regard to the discovery and inspection of workshops. This is to be accounted for by (1) the lack of central control, and (2) the absence of facilities for enabling local authorities to undertake the inspection of outworkers.

These defects are partly remedied by the Factory Act of 1901, which requires that lists of out-workers shall be sent to the district councils, and provides for a certain amount of central control, by requiring local authorities to keep registers of workshops, and to report on the administration of the Factory and Workshops Act. But it is probable that more control will have to be exercised by the central authority over the local bodies to compel them to appoint an adequate number of inspectors of workshops. This might be done by the method of grants-in-aid, the Government contributing towards the salaries of the inspectors, with power to withdraw the grant in case the local authorities do not come up to the required standard of efficiency.

In towns where special inspectors of workshops have been appointed, evidence is given that effective administration is possible under the present system of dual control. With the further extension of the regulation of home work, the proposal to transfer the entire supervision of workshops to the Home Office becomes more and more impracticable, for the discovery and inspection of domestic workshops can be undertaken only by those who are authorised to carry on a house-to-house visitation for sanitary purposes.

4. *Nature's Economics. By* Miss HELEN BLACKBURN.

Legislation regarding the economics of industry should be in harmony with the economics of nature, which requires of all human beings that they seek the control of their own surroundings as much as in them lies.

The old phrase, 'spear side and spindle side,' by which our forefathers expressed the industrial conditions of earlier days, indicates the direction of the chief occupation of women, while men and women worked into each other's hands in many directions.

By the aid of science, with its introduction of steam power, industrial economics entered a new era. We read of a parallel change going on in South Africa which illustrates this. The introduction of the plough which is drawn by cattle is robbing the native women of the field work which they regard as their right, for with the South African native the management of cattle is the exclusive privilege of men. So with ourselves by means of machinery the domestic arts of women have been carried into the province of men. They find themselves by no fault or choice of their own in competition with men.

The moral effects are more serious than the industrial. Home is no longer a school of domestic art. Legislation is invoked to readjust harmony.

By the common application of few rules and simple, nature provides harmonious variety. Our industrial legislation on the contrary works by exceptions, thereby bringing about class legislation, which always falls heaviest on the weakest.

In the textile trades women have natural special advantages over men, but in the greater number of trades the fitness of men or women for the work is a matter of personal capacity and circumstances. In these a very small consideration turns the scale and causes women to be regarded as rivals, not as helpmates.

Our economic jurisprudence, weakened by the exclusion of women from representation, induces the sentimental idea of control from without.

5. *The Regulation of Wages in Developed Industries.*
By Professor S. J. CHAPMAN, *M.A.*

This paper does not deal with the fundamental determinants of wages, but merely with the principles adopted for deliberately regulating them (where they are deliberately regulated), and the machinery by which the principles are applied. It is now commonly assumed that wages (whether time-rates or piece-rates) should vary with profits, but 'profits' may stand for several different conceptions. There are 'particular' profits—*i.e.*, the profits of particular firms; and 'general' or 'normal' profits—*i.e.*, 'marginal' profits; 'average' profits, in addition, are frequently referred to during disputes as to wages, but by these 'marginal' profits or 'normal' profits are to be understood as a rule. In some businesses in which the relations between the several human factors employed are close, wages may be settled by the rise and fall of 'particular' profits; but in general, if profits are to rank as determinants, the 'normal' profits in the industry must be understood. The regulation of wages by normal profits is not so simple as it appears to be at first sight, since the determination of profits, with any degree of exactness, in most industries is impossible. However, in some industries, such as coal-mining, iron-smelting, and cotton-spinning, the movements in the prices of some few commodities may be taken as a rule to indicate the movements in profits. For instance, in the cotton industry 'margins' are taken to vary as normal profits, and by 'margins' are meant the differences between the market prices of raw cotton and of yarns. It can be taken that in some industries the determination of normal profits may be made usually with sufficient ease and accuracy for practical purposes. Even in these cases, however, the question of the regulation of wages is not settled, for it has further to be decided (1), whether wages shall vary directly, and at the same rate, as normal profits, and (2), how frequently a movement shall take place, *i.e.*, over how long a period the normal profits shall be reckoned. Arbitration seems to imply that the rate at which wages and profits shall be made to vary together can be fixed for all time or a long period of time; and the objection has consequently been made to arbitration that when it is admitted fully into an industry the employés are prevented from rising above a certain position. Such dislike to arbitration as exists, is largely grounded on the desire to render possible at any time resettlements of the rates between profits and wages. But it is not yet clearly perceived as a rule, that many strikes might be avoided by an appeal to arbitration for the settlement of matters of fact and calculation, after the fundamental principle upon which the readjustment of wages was to be made had been accepted by both parties. Again, no little difficulty has been caused by the fact that the question of the intervals between readjustments of wages has never been exhaustively discussed. The advocates of sliding-scales—which have also met with the same criticism as arbitration—have frequently assumed that the 'sliding' should be ideally continuous, so that wages and profits might feel alike the 'ups and downs' of the industry. To such an arrangement, however, and to any arrangement closely approximating to it, the gravest objections can be found, at any rate at the present time. It is obvious that the method of regulating wages must be different under different industrial forms.

6. *Some Urgent Needs of a Great City.* *By* Miss L. A. WALKINGTON.

The paper refers to the city of Belfast, and five urgent needs are pointed out. (1) *Homes for the dying.*—These are required for refined, educated, poor gentlemen and ladies, such as tutors and governesses, who for various causes cannot be nursed by friends. Their essentials are privacy and rapid admission on proper recommendation, without the delay of election. (2) *Open spaces for children's playgrounds.*—Great danger and inconvenience are caused by children, who have no proper playground provided for them, playing in the streets. Playgrounds should be provided, one in each crowded locality, not necessarily large or elaborately got up, but with benches, shelters, sand, and trees. The resulting benefits would be found in improved health and happiness of the children and comfort of pedestrians. (3) *Libraries in raised type for the blind.*—An outline of the history of raised-type books is given. They are of great benefit, and free libraries containing them are needed. (4) *Clubs for working girls.*—These should have suitable eating and sleeping accommodation, and are needed in working districts for mill and factory workers, who are exposed to danger when lodging in private houses. They should be near the girls' work, cheap, attractive, and run on business principles. (5) *Homes for inebriates.*—There is only one such home in Ireland, that for inebriate women in Belfast. More are needed, and further legislation is required.

7. *The Increase in Consumption in Ireland.* *By* ROBERT BROWN.

The author drew attention to the following statistics of consumption, a disease which is accountable for nearly one sixth of all the deaths in Ireland and about one half of all *deaths between* the ages of fifteen and thirty-five.

Deaths from Consumption per 10,000 *of the Population.*

England and Wales		Ireland
Average: 1870–1875	24	19·5
1880–1885	19	21
1895–1900	14	21·3
1900	13·5	22·8

England and Wales are reducing their death-rate from consumption at a fairly rapid rate, and an average reduction of about 40 per cent. in thirty years is taking place in every civilised country in the world of which statistics are to hand, except in Ireland, where the death-rate from consumption is steadily on the increase; and although both Dublin and Belfast have made some progress it is very small compared with what has been made by Glasgow and Paisley.

Death-rate per 10,000 *of the Population from Consumption.*

Glasgow		Paisley	Dublin	Belfast
1880–85	31	27	35	39
1896–1900	20	18	32	33

The author considers that as a general rule the sanitary authorities are very much behind in the way they perform their duties and tolerate a state of filth in Ireland which would not be permitted in any other country. The people are content to live in a state of dirt and discomfort, having little desire for cleanliness in their persons or homes, and a glance at the pavements and railway carriages will show visitors that the filthy habit of spitting is indulged in here to an extent to which they happily are not accustomed.

It is suggested that the increased use of bread and tea, till they are now almost the sole diet of the working classes, is sapping the vitality of the latter, and is probably the chief cause of their increasing liability to consumption. Everyone who knows how the working classes live will agree that an immense proportion of them drink large quantities of strong stewed tea four or even five times a day. Prepared and taken thus, it does harm chiefly by dulling the craving for food, and so enables the people to be satisfied with an insufficient dietary. The fact, also, that it is always 'bite and sup' with them, and the food is washed down quite unmasticated, still further taxes the unfortunate stomach.

SECTION G.—ENGINEERING.

PRESIDENT OF THE SECTION—Professor JOHN PERRY, D.Sc., F.R.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

THIS Section has had sixty-six Presidents, all different types of engineer. As each has had perfect freedom in choosing the subject for his Address, and each has known of the rule that Presidential Addresses are not subject to debate afterwards,[1] and as, being an engineer, he has always been a man of originality, of course he has always chosen a subject outside his own work. An engineer knows that the great inventions, the great suggestions of change in any profession, come from outsiders. Lawyers seem like fish out of water when trying to act as lawmakers. The radical change that some of us hope to see before we die in the construction of locomotives will certainly not come from a locomotive superintendent who cannot imagine a locomotive which is not somehow a lineal descendant of the Rocket.

Hence it is that in almost every case the President of this Section has devoted a small or large part of his Address to the subject of the education of engineers. I grant that every President has devoted his life to the education of one engineer—himself—and it is characteristic of engineers that their professional education proceeds throughout the whole of their lives. Perhaps of no other men can this be said so completely. To utilise the forces of Nature, to combat Nature, to comprehend Nature as a child comprehends its mother, this is the pleasure and the pain of the engineer.[2] A mere scientific man analyses Nature: takes a phenomenon, dissects it into its simpler elements, and investigates these elements separately in his laboratory. The engineer cannot do this. He must take Nature as she is, in all her exasperating complexity. He must understand one of Nature's problems as a whole. He must have all the knowledge of the scientific man, and ever so much more. He uses the methods of the scientific man, and adds to them methods of his own. The name given to these scientific methods of his own or their results is sometimes 'common-sense,' sometimes 'character,' or 'individuality,' or 'faculty,' or 'business ability,' or 'instinct.' They come to him through a very wide experience of engineering processes, of acquaintance with things and men. No school or college can do more than prepare a young man for this higher engineering education which lasts through life. Without it a man follows only rule of thumb, like a sheep following the bell-wether, or else he lets his inventiveness or love of theory act the tyrant.

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[1] The Committees of Sections G and L having arranged a discussion on 'The Education of Engineers,' and this Address being regarded as opening the discussion, the rule is not in force this year.

[2] Of all the unskilled labour of the present day, surely that of the modern poet is the most grotesque. How much more powerful and powerless man seems to us now; how much more wonderful is the universe than it was to the ancients! Yet our too learned poets prefer to copy and recopy the sentiments of the ancients rather than try to see the romance which fills the lives of engineers and scientific men with joy.

When a man has become a great engineer, and he is asked how it happened, what his education has been, how young engineers ought to be trained, as a rule it is a question that he is least able to answer, and yet it is a question that he is most ready to answer. He sees that he benefited greatly by overcoming certain difficulties in his life; and forgetting that every boy will have difficulties enough of his own, forgetting that although a few difficulties may be good for discipline many difficulties may be overwhelming, forgetting also that he himself is a very exceptional man, he insists upon it that those difficulties which were personal to himself ought to be thrown in the path of every boy. It often happens that he is a man who is accustomed to think that early education can only be given through ancient classics. He forgets the dulness, the weariness of his schooldays. Whatever pleasure he had in youth—pleasure mainly due to the fact that the average Anglo-Saxon boy invents infinite ways of escaping school drudgery—he somehow connects with the fact that he had to learn classics. Being an exceptional boy, he was not altogether stupefied, and did not altogether lose his natural inclination to know something of his own language; and he is in the habit of thinking that he learnt English through Latin, and that ancient classics are the best mediums through which an English boy can study anything.[1] The cleverest men of our time have been brought up on the classics, and so the engineer who cannot even quote correctly a tag from the Latin grammar, who never knew anything of classical literature, insists upon it that a classical education is essential for all men. He forgets the weary hours he spent getting off Euclid, and the relief it was to escape from the class-room not quite stupefied, and he advocates the study of pure mathematics and abstract dynamics as absolutely necessary for the training of the mind of every young engineer. I have known the ordinary abominable system of mathematical study to be advocated by engineers who, because they had passed through it themselves, had really got to loathe all kinds of mathematics higher than that of the grocer or housekeeper. They said that mathematics had trained their minds, but they did not need it in their profession. There is no profession which so much requires a man to have the mathematical tool always ready for use on all sorts of problems, the mathematical habit of thought the one most exercised by him; and yet these men insist upon it that they can get all their calculations done for them by mathematicians paid so much a week. If they really thought about what they were saying, it would be an expression of the greatest contempt for all engineering computation and knowledge. He was pitchforked into works with no knowledge of mathematics, or dynamics, or physics, or chemistry, and, worse still, ignorant of the methods of study which a study of these things would have produced; into works where there was no man whose duty it was to teach an apprentice; and because he, one in a thousand, has been successful, he assures us that this pitchforking process is absolutely necessary for every young engineer. He forgets that the average boy leaves an English school with no power to think for himself, with a hatred for books, with less than none of the knowledge which might help him to understand what he sees, and he has learnt what is called mathematics in such a fashion that he hates the sight of an algebraic expression all his life after.

I do not want to speak of boys in general. I want only to speak of the boy who may become an engineer, and before speaking of his training I want to mention his essential natural qualification—that he really wishes to become an engineer. I take it to be a rule to which there are no exceptions that no boy ought to enter a profession—or, rather, to continue in a profession—if he does not love it. We all know the young man who thinks of engineering things during office hours and never thinks of them outside office hours. We know how his fond mother talks of her son as an engineer who, with a little more family influence and personal favour, and if there was not so much competition in the profession, would do so well. It is true, family influence may perhaps get such a man a better position, but he will never be an engineer. He is not fit even to be a hewer of wood and drawer of water to engineers. Love for his profession keeps a man alive to its interests all his time, although, of course, it does not prevent his taking an interest in all sorts of other things as well; but it is only a professional problem that warms him through with enthusiasm. I think we may assume that there never yet was an engineer worth his salt who was not fond of engineering, and so I shall speak only of the education of the young man who is likely to be fond of engineering.

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[1] The very people who talk so much of learning English through Latin neglect in the most curious ways those Platt-Deutsch languages, Dutch and Scandinavian, a knowledge of which is ten times more valuable in the study of what is becoming the speech of the world. And how they do scorn Lowland Scotch!

How are we to detect this fondness in a boy? I think that if the general education of all boys were of the rational kind which I shall presently describe, there would be no great difficulty; but as the present academic want of system is likely to continue for some time, it is well to consider things as they are. Mistakes must be made, and the parent who tries during the early years of his offspring to find out by crafty suggestion what line his son is likely to wish to follow will just as probably do evil by commission as the utterly careless parent is likely to do evil by omission. He is like the botanical enthusiast who digs up plants to see how they are getting on. But in my experience the Anglo-Saxon boy can stand a very great deal of mismanagement without permanent hurt, and it can do no kind of boy any very great harm to try him on engineering for a while. Even R. L. Stevenson, whose father seems to have been very persistent indeed in trying to make an engineer of him against his will, does not seem, to a Philistine like myself, to have been really hurt as a literary man through his attendance on Fleeming Jenkins' course at Edinburgh—on the contrary, indeed. It may be prejudice, but I have always felt that there is no great public person of whom I have ever read who would not have benefited by the early training which is suitable for an engineer. I am glad to see that Mr. Wells, whose literary fame, great as it is, is still on the increase, distinguishes the salt of the earth or saviours of society from the degraded, useless, luxurious, pleasure-loving people doomed to the abyss by their having had the training of engineers and by their possessing the engineer's methods of thinking.

It may be that there are some boys of great genius to whom all physical science or application of science is hateful. I have been told that this is so, and if so I still think that only gross mismanagement of a youthful nature can have produced such detestation. For such curious persons engineering experience is, of course, quite unsuitable. I call them 'curious' because every child's education in very early years is one in the methods of the study of physical science; it is Nature's own method of training, which proceeds successfully until it is interfered with by ignorant teachers who check all power of observation and the natural desire of every boy to find out things for himself. If he asks a question, he is snubbed; if he observes Nature as a loving student, he is said to be lazy and a dunce, and is punished as being neglectful of school work. Unprovided with apparatus, he makes experiments in his own way, and he is said to be destructive and full of mischief. But however much we try to make the wild ass submit to bonds and the unicorn to abide by the crib, however bullied and beaten into the average schoolboy type, I cannot imagine any healthy boy suffering afterwards by part of a course of study suitable for engineers, for all such study must follow Nature's own system of observation and experiment. Well, whether or not a mistake has been made, I shall assume the boy to be likely to love engineering, and we have to consider how he ought to be prepared for his profession.

I want to say at the outset that I usually care only to speak of the average boy, the boy usually said to be stupid, ninety-five per cent. of all boys. Of the boy said to be exceptionally clever I need not speak much. Even if he is pitchforked into works immediately on leaving a bad school, it will not be long before he chooses his own course of study and follows it, whatever course may have been laid down for him by others. I recollect that when in 1863 I attended an evening class held in the Model School, Belfast, under the Science and Art Department, on Practical Geometry and Mechanical Drawing, there was a young man attending it who is now well known as the Right Honourable William J. Pirrie. He had found out for himself that he needed a certain kind of knowledge if he was to escape from mere rule-of-thumb methods in shipbuilding work; it could at that time be obtained nowhere in the North of Ireland except at that class, and of course he attended the class. For forty-two years the Science and Art Department, which has recently doubled its already great efficiency, has been giving chances of this kind to every clever young man in the country, from long before any Physical Science was taught in any English public school.[1] The one essential thing for the exceptional boy is that he shall find within his reach chances to take advantage of; chances of learning; chances of practice; and, over and above all, chances of meeting great men. It takes me off my subject a little, but I should like here to illustrate this matter from my own personal experience.

I had already been an apprentice for four years at the Lagan Foundry when I entered Queen's College for a course of Civil Engineering. I suppose that there never was on this earth a college so poorly equipped for a course of engineering study. Even the lecture-room—this lecture-room in which you are now sitting—was borrowed from the Physics Professor. There was a narrow passage, ironically called a 'Drawing Room,' and this was the only space reserved for engineering in a town whose engineering work was even then very important. There were some theodolites and levels and chains for surveying, but nothing else in the way of apparatus. But there was as Professor a man of very great individuality; he acted as President of this Section twenty-eight years ago. I can hardly express my obligations to Professor James Thomson. It was my good fortune to be a pupil both of this great man and of his younger brother Lord Kelvin, as well as of Dr. Andrews. It is not because these three men were born in Belfast that we here call them great. It is not because Tait, late of Edinburgh, and Purser, now the President of Section A, were professors at this College that we call them great All the scientific men of the world are agreed to call these men very great indeed. To come in contact with any of them, even for a little while, as a student altered for ever one's attitude to Nature. It was not that they gave us information, knowledge, facts. The syllabuses of their courses of study were nothing like so perfect as that of the smallest German polytechnic. And yet if a youth with a liking for physical science had gone to a German Gymnasium to the age of nineteen, and had become a walking encyclopædia on leaving one's polytechnic at the age of twenty-four, the course of that life-study would not have done for him as much good as was done by a month's contact with one of these men. People call it 'personal magnetism,' and think there is something occult about it. In truth, they revealed to the student that he himself was a man, that mere learning was unimportant, that one's own observation of some common phenomenon might lead to important results unknown to the writers of books. They made one begin to think for oneself for the first time. Let me give an example of how the thing worked.

James Thomson was known to me as the son of the author of my best mathematical books, but more particularly as the man who had first used Carnot's principle in combination with the discovery of Joule, and I often wondered why Rankine and Clausius and Kelvin got all the credit of the discovery of the second law of thermodynamics. Men think of this work of his merely as having given the first explanation of regelation of ice and the motion of glaciers. He was known to me as the inventor of the Thomson Turbine and Centrifugal Pump and Jet Pump. His name was to be found here and there in all my text-books, always in connection with some thoroughly well-worked-out investigation, as it is to be found in all good text-books now; for wherever he left a subject, there that subject has remained until this day; nobody has added to it or found a mistake in it. He was to me a very famous man, and yet he treated me as a fellow-student. One of his early lectures was about flowing water, and he told us of a lot of things he had observed, which I also had observed without much thought; and he showed how these simple observations completely destroyed the value of everything printed in every text-book on the subject of water flowing over gauge-notches, even in the otherwise very perfect Rankine. I felt how stupid I had been in not having drawn these conclusions myself, but in truth till then I had never ventured for a moment to criticise anything in a book. I have been a cautious critic of all statements in text-books ever since. If any engineer wants to read what is almost the most instructive paper that has ever been written for engineers, let him refer to the latest paper written by James Thomson on this subject.[1] The reasoning there given was given to me in lectures in this very room in 1868, and had been given to students for many years previous.

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[1] I once stated that my workshop at Clifton College in 1871 was the first school workshop in England. I understand that this is a mistake; there had been a workshop at Rossall for some years. But I believe I am right in saying that my physical laboratory at Clifton was the first school laboratory in England. These ideas were not mine; they were those of the Headmaster, now the Bishop of Hereford.

Again, soon afterwards, he let me see that although I had often looked at the whirlpool in a basin of water when the central bottom hole is open, and although I had read Edgar Allen Poe's mythical description of the Maëlstrom, I had been very much too careless in my observation. Among other things, Thomson had observed that particles of sand gradually passed along the bottom towards the hole. When he found out the cause of this, it led him at once to several discoveries of great importance. Indeed, the study of this simple observation gave rise to all his work on (1) What occurs at bends of pipes and channels, and why rivers in alluvial plains bend more and more; (2) The explanation of the curious phenomena that accompany great forest fires; (3) The complete theory of the great wind circulation of the earth, published in its final form as the Bakerian Lecture of the Royal Society in 1892.

But why go on? He taught me to see that the very commonest phenomenon had still to reveal important secrets to the understanding eye and brain, and that no man is a true student unless he is a discoverer. And so it was with Kelvin and Andrews. Their names were great before the world, and yet they treated one as a fellow-student. Is any expenditure of money too large if we can obtain great men like these for our Engineering Colleges? Money is wanted for apparatus, and more particularly for men, and we spend what little we have on bricks and mortar!

The memory of a man so absolutely honest as Professor James Thomson was compels me to say here that I was in an exceptionally fit state to benefit by contact with him, for I hungered for scientific information.[2] I do not think that there was so much benefit for the average student whose early education had almost unfitted him for engineering studies. To work quantitatively with apparatus is good for all students, but it is absolutely necessary for the average student, and, as I said before, there was no apparatus. Also the average student cannot learn from lectures merely, but needs constant tutorial teaching, and the Professor had no assistant.

Anybody who wants to know what kind of engineering school there ought to be in such a college as this can see excellent specimens (sometimes several in one town) in Glasgow, Birmingham, Liverpool, London, Manchester, Leeds, Bristol, Nottingham, Edinburgh, and other great cities. There the fortunate manufacturers have given many hundreds of thousands of pounds for instruction in applied science (engineering). In America the equipment of such schools is much more thorough, and there are large staffs of teachers, for fortunate Americans have contributed tens of millions of pounds for this kind of assistance to the rising generation. Germany and Switzerland compete with America in such preparation for supremacy in manufacture and engineering, and nearly every country in the world is more and more recognising its importance as they see the great inventions of Englishmen like Faraday and Perkin and Hughes and Swan developed almost altogether in those countries which believe in education. Even one hundred thousand pounds would provide Queen's College, Belfast, with the equipment of an engineering school worthy of its traditions and position, and Belfast is a city in which many large business fortunes have been made.

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[1] *Brit. Assoc. Report*, 1876, pp. 243-266.

[2] Some of our most successful graduates went direct to works from the Model School, Belfast, and afterwards attended this College. No school in the British Islands could have given better the sort of general education which I recommend for all boys. English subjects were especially well taught, so that boys became fond of reading all manner of books. There were good classes in freehand and machine drawing, classes in chemistry and physics (at that time I believe that there were no such classes in any English public school), and the teaching of mathematics was good. Some of the masters started classes also under the Science and Art Department. Some of the masters had much individuality, and there was no outside examination to restrain it; there was only encouragement. Evidence has been given before a committee of the London School Board as to the excellence of the teaching at this school forty years ago. Foreign languages were not in the regular curriculum, but they could be studied by boys inclined that way; and in my opinion this is the position that all languages other than English ought to take in any British school With such preparation a boy was eager and able to understand what went on in engineering works from his first day there.

It is interesting to note that the present arrangements of the Royal University of Ireland, with which this College is affiliated, are such that most of the successful graduates in engineering of Queen's University would now be debarred from taking the degree. Even in London University, Latin is not a compulsory subject for degrees in science; Ireland has taken a step backwards towards the Middle Ages at the very time when other countries are stepping forward.

Well-equipped schools of applied science are getting to be numerous, but I am sorry to say that only a few of the men who leave them every year are really likely to become good engineers. The most important reason for this is that the students who enter them come usually from the public schools; they cannot write English; they know nothing of English subjects; they do not care to read anything except the sporting news in the daily papers; they cannot compute; they know nothing of natural science; in fact, they are quite deficient in that kind of general education which every man ought to have.

I am not sure that such ignorant boys would not benefit more by entering works at once than by entering a great engineering school. They cannot follow the College courses of instruction at all, in spite of having passed the entrance examination by cramming. Whereas after a while they do begin to understand what goes on in a workshop; and if they have the true engineer's spirit, their workshop observation will greatly correct the faults due to stupid schoolwork.[1]

Perhaps I had better state plainly my views as to what general education is best for the average English boy. The public schools of England teach English through Latin, a survival of the time when only special boys were taught at all, and when there was only one language in which people wrote. Now the *average* boy is also taught Latin, and when he leaves school for the army or any other pursuit open to average boys he cannot write a letter, he cannot construct a grammatical sentence, he cannot describe anything he has seen. The public-school curriculum is always growing, and it is never subtracted from or rearranged. There is one subject which ordinary schoolmasters can teach well—Latin.[2]

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[1] When I was young I remember that there were many agricultural colleges in Ireland; they have all but one been failures. Why? Because the entering pupils were not prepared by early education to understand the instruction; this had done as much as possible to unfit them.

[2] Only one subject—Latin—is really educational in our schools. I do not mean that the average boy reads any Latin author after he leaves school, or knows any Latin at all ten years after he leaves school. I do not mean that his Latin helps him even slightly in learning any modern language, for he is always found to be ludicrously ignorant of French or German, even after an elaborate course of instruction in these languages. I do not mean that his Latin helps him in studying English, for he can hardly write a sentence without error. I do not mean that it makes him fond of literature, for of ancient literature or history he never has any knowledge except that Cæsar wrote a book for the third form, and on English literature his mind is a blank. But I do mean that as the ordinary public-school master is really able to give a boy easy mental exercises through the study of Latin, this subject is in quite a

The other usual nine subjects have gradually been added to the curriculum for examination purposes; they are taught in water-tight compartments—or, rather, they are only crammed, and not taught at all. Our school system resembles the ordinary type of old-established works, where gradual accretion has produced a higgledy-piggledy set of shops which one looks at with stupefaction, for it is impossible to get business done in them well and promptly, and yet it seems impossible to start a reform anywhere. What is wanted is an earthquake or a fire—a good fire—to destroy the whole works and enable the business to be reconstructed on a consistent and simple plan. And for much the same reason our whole public-school system ought to be 'scrapped.' What we want to see is that a boy of fifteen shall be fond of reading, shall be able to compute, and shall have some knowledge of natural science; or, to put it in another way, that he shall have had mental training in the study of his own language, in the experimental study of mathematics, and in the methods of the student of natural science. Such a boy is fit to begin any ordinary profession, and whether

different position from that of the others. If any proof of this statement is wanted, it will be found in the published utterances of all sorts of men—military officers, business men, lawyers, men of science, and others—who, confessedly ignorant of 'the tongues,' get into a state of rapture over their school experiences and the efficiency of Latin as a means of education. All this comes from the fact, which schoolboys are sharp enough to observe, that English schoolmasters can teach Latin well, and they do not take much interest in teaching anything else. It is a power inherited from the Middle Ages, when there really was a simple system of education. I ask for a return to simplicity of system. English (the King's English; I exclude Johnsonese) is probably the richest, the most complex language, the one most worthy of philologic study; English literature is certainly more valuable than any ancient or modern literature of any one other country, yet admiration for it among learned Englishmen is wonderfully mixed with patronage and even contempt. At present, is there one man who can teach English as Latin is taught by nearly every master of every school? Just imagine that English could be so taught by teachers capable of rising to the level of our literature!

I have often to give advice to parents. I find the average parent exceedingly ignorant of his son's character or inclinations or ability. He pays a schoolmaster handsomely for taking his son off his hands except during holidays. During the holidays, so terrible to a parent, he sees his son as little as possible. One question always asked is: Do you think it better to have 'theoretical' instruction (they always call it by this absurd name) before or after an actual apprenticeship in works? Of course, such a question cannot be answered offhand. You tell the parent, to his great astonishment, that you must see the boy himself. When at length you see him, the chances are that you will find him to be what the schoolmasters are making of all our average boys. No part of his school work has been a pleasure to him, and, although he has had to work hard at his books, not one of the above three powers is his—power to use books and to write his own language; the language of his nurse, his mother, his mistress that is to be, his enemies and friends; the only language in which he thinks—power to compute and a liking for computation—power to understand a little of natural phenomena. Honestly I practically never find that such a boy has had any education at all except what he has obtained at home or from his school companions or from his sports. Even his sports are to keep him healthy of body only and not at all to cultivate his mental powers. Those old games like 'Prisoners' Base,' which really developed in a wonderful way not only all the muscles of the body, but also the thinking power, are scorned in the public schools. Think now how such a boy is handicapped if we pitchfork him into works where it is nobody's duty to teach him anything, or send him to college, where he cannot understand the lectures. Of course, if he is very eager to be an engineer he will, by hook or by crook, get to understand things. I have met some such men—clever, successful engineers in spite of all sorts of adverse circumstances—but the best of them are willing to admit that they are, and have always been, greatly hurt by the absence of the three powers which I have specified. And if this has been so in the past, when the scientific principles underlying engineering have been simple, how much more so is it now, when every new discovery in physics is producing new branches of engineering!

he is to enter the Church, or take up medicine or surgery, or become a soldier, every boy ought to have this kind of training. When I have advocated this kind of education in the past I have usually been told that I was thinking only of boys who intend to be engineers; that it was a specialised kind of instruction. But this is very untrue. Let me quote from the recommendations of the 1902 Military Education Committee (Report, p. 5):—

'The fifth subject which may be considered as an essential part of a sound general education is experimental science; that is to say, the science of physics and chemistry treated experimentally. As a means of mental training, and also viewed as useful knowledge, this may be considered a necessary part of the intellectual equipment of every educated man, and especially so of the officer, whose profession in all its branches is daily becoming more and more dependent on science.' When statements of this kind have been made by some of us in the past, nobody has paid much attention; but I beg you to observe that the headmaster of Eton and the headmaster of St. Paul's School are two of the members of the important Committee who signed this recommendation, and it is impossible to ignore it. Last year, for the first time, the President of the Royal Society made a statement of much the same kind, only stronger, in his annual address. I am glad to see that the real value of education in physical science is now appreciated; that mere knowledge of scientific facts is known to be unimportant compared with the production of certain habits of thought and action which the methods of scientific study usually produce.

As to English, the Committee say: 'They have no hesitation in insisting that a knowledge of English,[1] as tested by composition, together with an acquaintance with the main facts of the history and geography of the British Empire, ought in future to hold the *first* place in the examination and to be exacted from all candidates.' The italics are mine. It will be noticed that they say nothing about the practical impossibility of obtaining teachers. As to mathematics, the Committee say: 'It is of almost equal importance that every officer should have a thorough grounding in the elementary part of mathematics. But they think that elementary mechanics and geometrical drawing, which under the name of practical geometry is now often used as an introduction to theoretical instruction, should be added to this part of the examination, so as to ensure that at this stage of instruction the practical application of mathematics may not be left out of sight.' As Sir Hugh Evans would have said, 'It is a very discretion answer—the meaning is good'; but I would that the Committee had condemned abstract mathematics for these army candidates altogether.

This report appears in good time. It would be well if Committees would sit and take evidence as to the education of men in the other professions entered by our average boys. It is likely that when an authoritative report is prepared on the want of education of clergymen, for example, exactly the same statements will be made in regard to the general education which ought to precede the technical training; but perhaps a reference may be made in the report to the importance of a study of geology and biology as well as physical science. Think of the clergyman being able to meet his scientific enemies in the gate!

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[1] This Committee recommends for the Woolwich and Sandhurst candidates a reform that has already been carried out by London University. No dead language is to be compulsory, but unfortunately some language other than English is still to be compulsory. Those boys, of whom there are so many, who dislike and cannot learn another language are still to be labelled 'uneducated.' Must there, then, be national defeat and captivity before our chosen race gives up its false academic gods? We think of education in the most slovenly fashion. The very men who say that *utility* is of no importance are the men who insist on the usefulness of a knowledge of French or German. They say that a man is illiterate if he knows only English, although he may be familiar with all English literature and with other literatures through translations. The man who has passed certain examinations in his youth and never cares to read anything is said to be educated. The men of the city of the Violet Crown, were they not educated? And did they know any other than their own language?

Thanks mainly to the efforts of a British Association Committee, really good teaching of experimental science is now being introduced into all public schools, in spite of most persistent opposition wearing an appearance of friendliness. In consequence, too, of the appointment of a British Association Committee last year, at what might be called the psychological moment, a great reform has already begun in the teaching of mathematics.[1] Even in the regulations for the Oxford Locals for 1903 Euclid is repudiated. It seems probable that at the end of another five years no average boy of fifteen years of age will have been compelled to attempt any abstract reasoning about things of which he knows nothing; he will be versed in experimental mathematics, which he may or may not call mensuration; he will use logarithms, and mere multiplication and division will be a joy to him; he will have a working power with algebra and sines and cosines; he will be able to tackle at once any curious new problem which can be solved by squared paper; and he will have no fear of the symbols of the infinitesimal calculus. When I insist that a boy ought to be able to compute, this is the sort of computation that I mean. Five years hence it will be called 'elementary mathematics.' Four years ago it was an unorthodox subject called 'practical mathematics,' but it is establishing itself in every polytechnic and technical college and evening or day science school in the country. Several times I have been informed that on starting an evening class, when plans have been made for a possible attendance of ten or twenty students, the actual attendance has been 200 to 300. Pupils may come for one or two nights to a class on academic mathematics, but then stay away for ever; a class in practical mathematics maintains its large numbers to the end of the winter.[2]

Hitherto the average boy has been taught mathematics and mechanics as if he were going to be a Newton or a Laplace; he learnt nothing and became stupid. I am sorry to say that the teaching of mechanics and mechanical engineering through experiment is comparatively unknown. Cambridge writers and other writers of books on experimental mechanics are unfortunately ignorant of engineering. University courses on engineering—with one splendid exception, under Professor Ewing at Cambridge—assume that undergraduates are taught their mechanics as a logical development of one or two axioms; whereas in many technical schools under the Science and Art Department apprentices go through a wonderfully good laboratory course in mechanical engineering. We really want to give only a few fundamental ideas about momentum and the transformations of energy and the properties of materials, and to give them from so many points of view that they become part of a student's mental machinery, so that he uses them continually. Instead of giving a hundred labour-saving rules which must be forgotten, we ought to give the one or two ideas which a man's common-sense will enable him to apply to any problem whatsoever and which cannot be forgotten. A boy of good mathematical attainments may build on this experimental knowledge afterwards a superstructure more elaborate than Rankine or Kelvin or Maxwell ever dreamt of as being possible. Every boy will build some superstructure of his own.

I must not dwell any longer on the three essential parts of a good general education which lead to the three powers which all boys of fifteen ought to possess; power to use books and to enjoy reading; power to use mathematics and to enjoy its use; power to study Nature sympathetically. English Board School boys who go to evening classes in many technical schools after they become apprentices are really obtaining this kind of education. The Scotch Education Board is trying to give it to all boys in primary and secondary schools. It will, I fear, be some time before the sons of well-to-do parents in England have a chance of obtaining it.

When a boy or man of any age or any kind of experience enters an engineering college and wishes to learn the scientific principles underlying a trade or profession, how ought we to teach him? Here is the reasonable general principle which Professors Ayrton and Armstrong and I have acted upon, and which has so far led us to much success. Whether he comes from a bad or a good school, whether he is an old or young boy or man, approach his intelligence through the knowledge and experience he already possesses. This principle involves that we shall compel the teacher to take the pupil's point of view[1] rather than the pupil the teacher's: give the student a choice of many directions in which he may study; let lectures be rather to instruct the student how to teach himself than to teach him; show the student how to learn through experiment, and how to use books, and, except for suggestion and help when asked for, leave him greatly to himself. If a teacher understands the principle he will have no difficulty in carrying it out with any class of students. I myself prefer to have students of very different qualifications and experience in one class because of the education that each gives to the others. Usually, however, except in evening classes, one has a set of boys coming from much the same kind of school, and, although perhaps differing considerably as to the places they might take in an ordinary examination, really all of much the same average intelligence. Perhaps I had better describe how the principle is carried out in one case—the sons of well-to-do parents such as now leave English schools at about fifteen years of age.

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[1] Discussion last year and report of Committee, published by Macmillan.

[2] To many men it will seem absurd that a real working knowledge of what is usually called higher mathematics, accompanied by mental training, can be given to the average boy. In the same way it seemed absurd 500 years ago that power to read and write and cipher could be given to everybody. These general beliefs of ours are very wonderful.

It was for such boys that the courses of instruction at the Finsbury Technical College (the City and Guilds of London Institute) were arranged twenty-two years ago. It was attempted to supply that kind of training which ought already to have been given at school, together with so much technical training as might enable a boy at the end of a two years' course to enter any kind of factory where applied science was important, with an observing eye, an understanding brain, and a fairly skilful hand. The system, in so far as it applies to various kinds of mechanical engineering, will be found described in one of a small collection of essays called 'England's Neglect of Science,' pp. 57–67.[2] I am sure that any engineer who reads that description will feel satisfied that it was the very best course imaginable for the average boy of the present time. A boy was taught how he must teach himself after he entered works. If after two or three years in the works he cared to go for a year or so to one of the greater colleges, or did not so care, it was assumed that he had had such a training as would enable him to choose the course which was really the best for him.

Old Finsbury students are to be found everywhere in important posts. The experiment has proved so successful that every London Polytechnic, every Municipal Technical School in the country, has adopted the system, and in the present state of our schools I feel sure that all important colleges ought to adopt the Finsbury system. It hardly seems appropriate to apply the word 'system' to what was so plastic and uncrystallised and had nothing to do with any kind of ritual.

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[1] Usually it is assumed that there is only one line of study. In mathematics it is assumed that a boy has the knowledge and power and past experience and leisure of an Alexandrian philosopher. In mechanics we assume the boy to be fond of abstract reasoning, that he is a good geometrician who can do the most complex things in geometrical conics, but cannot possibly take in the simplest idea of the calculus.

[2] The ideas in this Address have been put forward many times by Professor Ayrton and myself. See the following, among other publications:—*England's Neglect of Science* (Fisher Unwin); *Practical Mechanics*, 1881 (Cassell); *Applied Mechanics*, 1897 (Cassell); *The Steam Engine, &c.*, 1898 (Macmillan); *The Calculus for Engineers*, 1897 (Arnold); Recent Syllabuses and Examination Papers of the Science and Art Department in Subjects I., VII., V*p*, and XXII.; Summary of Lectures on Practical Mathematics (Board of Education); The Work of the City and Guilds Central Technical College (*Journal of the Society of Arts*, July 9, 1897); Inaugural Lecture at Finsbury, 1879; Address at the Coventry Technical Institute, February 1898; 'Education of an Electrical Engineer' (*Journal of the Society of Telegraph Engineers and of Electricians*, September 1882); Presidential Address, Institution of Electrical Engineers, January 1892; 'The Best Education for an Engineer' (*Nature*), October 12, 1899; Address at a Drawing-room Meeting, March 1887.

The Professors were given a free hand at Finsbury, and there were no outside examiners. I need not dwell upon the courses in Chemistry and Physics; some critics might call the subjects *Rational* Chemistry and Applied Physics; they were as different from all other courses of study in these subjects as the courses on Rational Mathematics and Mechanics differed from all courses elsewhere. The course on Mechanics was really one on Mechanical Engineering. There were workshops in wood and iron, not to teach trades, but rather to teach boys the properties of materials. There were a steam-engine and a gas-engine, and shafting and gearing of many kinds, and dynamos which advanced students in turn were allowed to look after under competent men. There was no machine which might not be experimented with occasionally. Elementary and advanced courses of lectures were given; there was an elaborate system of tutorial classes, where numerical and squared paper exercise work was done; there were classes in experimental plane and solid geometry, including much graphical calculation; boys were taught to make drawing-office drawings in pencil only, and tracings and blue prints, such as would be respected in the workshop, and not the ordinary drawing-class drawings, which cannot be respected anywhere; but the most important part of the training was in the Laboratory, in which every student worked, making quantitative experiments. An offer of a 100-ton testing-machine for that laboratory was made but refused; the advanced students usually had one opportunity given them of testing with a large machine, but not in their own laboratory. I consider that there is very little educational value in such a machine; the student thinks of the great machine,[1] and not of the tiny specimen. Junior students loaded wires and beams, or twisted things with very visible weights, and saw exactly what was happening, or they studied vibrating bodies. Many hours were devoted to experiments on a battered, rusty old screw-jack, or some other lifting-machine, its efficiency under many kinds of load being determined, and students studied their observations using squared paper, as intently as if nobody had ever made such experiments before. There was one piece of apparatus, an old fly-wheel bought at a rag-and-bone shop, to which kinetic energy was given by a falling weight, which, I remember, occupied the attention of four white-headed directors of Electric Companies in 1882 (evening students) for many weeks. A casual first measurement led on to corrections for friction and stiffness of a cord, and much else of a most interesting kind. At the end of six weeks these gentlemen had gained a most thorough computational acquaintance with every important principle of mechanics, a knowledge never to be forgotten. They had also had a revelation such as comes to the true experimenter—but that is too deep a subject.

Perhaps teachers in the greater colleges will smile in a superior way when they hear of this kind of experimental mechanics being called engineering laboratory work. True, it was elementary mechanics; but is not every principle which every engineer constantly needs called a mere elementary principle of mechanics by superior persons? I find that these elementary principles are very much unknown to men who have passed through elaborate mathematical studies of mechanics. Students found out in that laboratory the worth of formulæ; they gained courage in making calculations from formulæ, for they had found out the extent of their own ignorance and knowledge.

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[1] These great testing-machines, so common in the larger colleges, seem to have destroyed all idea of scientific experiment. There is so much that the engineer wants to know, and yet laboratory people are persistently and lazily repeating old work suggested and begun by engineers of sixty years ago. For example, men like Fairbairn and Robert Napier would long ago have found out the behaviour of materials under combined stresses. We do not even know the condition of strength of iron or steel in a twisted shaft which is also a beam. The theory of strength of a gun or thick tube under hydraulic pressure is no clearer now than it was fifty years ago. The engineer asks for actual information derived from actual trial, and we offer him the 'cauld kail het again' stuff falsely called 'theoretical,' which is found in all the text-books (my own among others). These great colleges of university rank ought to recognise that it is their duty to increase knowledge through the work of their advanced students. The duty is not neglected in the electrical departments of some of the colleges. Perhaps the most instructive reference is to the work done at the Central Technical College of the City and Guilds Institute at South Kensington, as described by Professor Ayrton in some of the papers already referred to. I cannot imagine a better development of the Finsbury idea in the work of the highest kind of Engineering College.

I have never approved of elaborate steam-engines got up for students' laboratory exercise-work. A professor who had devoted much thought for a year to the construction of such a four-cylinder engine showed a friend how any one or any two or any three or all four cylinders, with or without jacketing, could be used in all sorts of ways. The friend ventured to say: 'This engine will be used just once and never after.' The professor was angry, but his friend proved to be right. The professor made experiments with it once himself with a few good students. Unfortunately it was not a sufficiently elaborate investigation for publication Afterwards he never had time personally to superintend such work; his assistants were busy at other things; his students could not be trusted with the engine by themselves, and to this day it stands in the laboratory a beautiful but useless piece of apparatus. At Finsbury there was an excellent one-cylinder engine with vaporising condenser. It drove the workshops and electric generators. On a field-day it drove an electric generator only, and perhaps thirty students made measurements. Each of them had already acted as stoker and engine-driver, as oiler and tester of the machinery, lighting fires, taking indicator diagrams, weighing coals, opening and closing cocks from seven in the morning to ten at night, so that everything was well known to him. They maintained three different steady loads for trials of three hours each. They divided into groups, one from each group ceasing to take a particular kind of observation every ten minutes and removing to another job. All watches were made to agree, and each student noted the time of each observation. These observations were:—Taking indicator diagrams, checking the speed indicator, taking temperature of feed-water, quantity of feed by meter (the meter had been carefully checked by gauge-notch, and every other instrument used by us had been tested weeks before), taking the actual horse-power passing through a dynamometer coupling on the shaft, taking boiler and valve-chest pressures and vacuum pressures on the roof and in the engine-room, weighing coals (the calorific value had already been tested), taking the horse-power given out by the dynamo, counting the electric lamps in use, and so on. Each student was well prepared beforehand. During the next week he reduced his own observations, and some of the results were gathered on one great table. One lesson that this taught could never be forgotten—how the energy of one pound of coal was disposed of. So much up the chimney or by radiation from boiler or steam-jacket and pipes; in condensation in the cylinder; to the condenser; in engine friction; in shaft friction, &c. I cannot imagine a more important lesson to a young engineer than this one taught through a common working engine. The students had the same sort of experience with a gas-engine. I need hardly say how important it was that the Professor himself should take charge of the whole work leading up to, during, and after such a field-day.

The difficulty about all laboratory exercise work worth the name is that of finding demonstrators and assistants who are wise and energetic. Through foolishness and laziness the most beautiful system becomes an unmeaning routine, and the more smoothly it works the less educational it is. In England just now the curse of all education is the small amount of money available for the wages of teachers—just enough to attract mediocre men. I have been told, and I can easily imagine, that such men have one talent over-developed, the talent for making their job softer and softer, until at length they just sit at a table, maintaining discipline merely by their presence, answering the questions of such students as are earnest enough to come and worry them. In such cases it is absolutely necessary to periodically upset their clockwork arrangements. After such an artificial earthquake one might be reminded of what occurred at the pool of Bethesda, whose waters had their healing property restored when the angel came down and troubled them. But for a permanently good arrangement there ought to be very much higher wages all round in the teaching profession.

No kind of engineering has developed so rapidly as the electrical. Why, it was at the meeting here in Belfast twenty-eight years ago (I remember, for I was a Secretary of Section A that year, and took the machine to pieces afterwards in Lord Kelvin's laboratory) that there was exhibited for the first time in these islands a small Gramme machine. This handmaid of all kinds of engineering is now so important that every young engineer may be called uneducated who has not had a training in that kind of mechanical engineering which is called electrical engineering. Professor Ayrton's laboratory at Finsbury is the model copied by every other electrical engineering laboratory in the world. He and I had the same notions; we had both been students of Lord Kelvin; we had worked together in Japan since 1875; but whereas I was trying to make my system of teaching mechanical engineering replace an existing system, or want of system, there was no existing system for his to replace. Thus it will be found that in every electrical engineering laboratory the elementary principles are made part of a pupil's mental machinery by many quantitative experiments, and nobody suggests that it is mere elementary physics which is being taught—a suggestion often enough made about the work in my mechanical laboratory. When students know these elementary principles well, they can apply their mathematics to the subject. As they advance in knowledge they are allowed to find out by their own experiments how their simple theories must be made more complex in real machines. Their study may be very complete, but, however much mathematics and graphical calculation may come in, their designs of electrical machinery are really based upon the knowledge acquired by them in the electrical and mechanical laboratories.

The electrical engineer has an enormous advantage over other engineers; everything lends itself to exact calculation, and a completed machine or any of its parts may be submitted to the most searching electrical and magnetic tests, since these tests, unlike those applied by other engineers, do not destroy the body tested. But for this very reason, as a finished product, the electrical engineer cannot have that training in the exercise of his judgment in actual practical work after he leaves a college that some other engineers must have. In tunnelling, earthwork, and building, in making railways and canals, the engineer is supremely dependent on the natural conditions provided for him, and these conditions are never twice the same. There are no simple laws known to us about the way in which sea and river currents will act upon sand and gravel, and engineers who have had to do with such problems are continually appealing to Nature, continually making observations and bringing to bear upon their work all the knowledge and habits of thought that all their past experience has given them. I do not know that there is any job which a good teacher would have greater pleasure in undertaking than the arrangement of a laboratory in which students might study for themselves such problems as come before railway, canal, river, harbour and coast-protection engineers; there is no such laboratory in existence at the present time, and in any case it could only be of use in the way of mere suggestion to an engineer who had already a good knowledge of his profession.

It was a curious illustration of mental inertia that the usual engineering visitor, even if he was a professor of engineering, always seemed to suppose that the work done at Finsbury was the same as that done in all the great engineering colleges. As a matter of fact no subject was taught there in the same manner as it was taught elsewhere.[1]

Most of the students were preparing for electrical or mechanical engineering, and therefore we thought it important that nearly every professor or demonstrator or teacher should be an engineer. I know of nothing worse than that an engineering student should be taught mathematics or physics or chemistry by men who are ignorant of engineering, and yet nothing is more common in colleges of applied science.[1] The usual courses are only suitable for men who are preparing to be mere mathematicians, or mere physicists, or mere chemists. Each subject is taken up in a stereotyped way, and it is thought quite natural that in one year a student shall have only a most elementary knowledge of what is to the teacher such a great subject. The young engineer never reaches the advanced parts which might be of use to him; he is not sufficiently grounded in general principles; his whole course is only a preliminary course to a more advanced one which there is no intention of allowing him to pursue, and, not being quite a fool, he soon sees how useless the thing is to him. The Professor of Chemistry ought to know that until a young engineer can calculate exactly by means of a principle, that principle is really unknown to him. For example, take the equation supposed to be known so well,

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[1] It is really ludicrous to see how all preachers on technical education are supposed by non-thinking people to hold the same doctrine. The people asking for reform in education differ from one another more than Erasmus and Luther, and John of Leyden and Knipperdoling.

$$2H_2 + O_2 = 2H_2O.$$

It is never understood by the ordinary elementary chemical student who writes it down so readily. Every one of the six cunning ways in which that equation conveys information ought to be as familiar to the young engineer as they are, or ought to be, to the most specialised chemist. Without this he cannot compute in connection with combustion in gas and oil engines and in furnaces. But I have no time to dwell on the importance of this kind of exact knowledge in the education of an engineer.

Mathematics and physics and chemistry are usually taugh in watertight compartments, as if they had no connection with one another. In an engineering college this is particularly bad. Every subject ought to be taught through illustrations from the professional work in which a student is to be engaged. An engineer has been wasting his time if he is able to answer the questions of an ordinary examination paper in chemistry or pure mathematics. The usual mathematical teacher thinks most of those very parts of mathematics which to an ordinary man who wants to *use* mathematics are quite valueless, and those parts which would be altogether useful and easy enough to understand he never reaches; and as I have said, so it is also in chemistry. Luckily, the physics professor has usually some small knowledge of engineering; at all events he respects it. When the pure mathematician is compelled to leave the logical sequence which he loves to teach mechanics, he is apt scornfully to do what gives him least trouble; namely, to give as 'mechanics' that disguised pure mathematics which forms ninety per cent. of the pretence of theory to be found in so many French and German books on machinery. As pure mathematical exercise work it is even meaner than the stupid exercises in school algebras; as pretended engineering it does much harm because a student does not find out its futility until after he has gone through it, and his enthusiasm for mathematics applied to engineering problems is permanently hurt. But how is a poor mathematical professor who dislikes engineering, feeling like Pegasus harnessed to a common waggon—how is he to distinguish good from evil? He fails to see how worthless are some of the books on 'Theoretical Mechanics' written by mathematical coaches to enable students to pass examinations. An engineer teaching mathematics would avoid all futilities; he would base his reasoning on that experimental knowledge already possessed by a student; he would know that the finished engineer cannot hope to remember anything except a few general principles, but that he ought to be able to apply these, clumsily or not, to the solution of any problem whatsoever. Of course he would encourage some of his pupils to take up Thomson and Tait, or Rayleigh's 'Sound,' or some other classical treatise as an advanced study.[2]

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[1] At the most important colleges the usual professor or tutor is often ignorant of all subjects except his own, and he generally seems rather proud of this; but surely in such a case a man cannot be said to know even his own subject.

[2] One sometimes finds a good mathematician brought up on academic lines taking to engineering problems. But he is usually *stale* and unwilling to go thoroughly into these practical matters, and what he publishes is particularly harmful, because it has such an honest appearance. When we do get, once in forty

Not only do I think that every teacher in an engineering college ought to have some acquaintance with engineering, but it seems to me equally important to allow a professor of engineering, who ought, above all things, to be a practical engineer, to keep in touch with his profession. A man who is not competing with other engineers in practical work very quickly becomes antiquated in his knowledge: the designing work in his drawing-office is altogether out of date; he lectures about old difficulties which are troubles no longer; his pupils have no enthusiasm in their work because it is merely academic and lifeless; even when he is a man distinguished for important work in the past his students have that kind of disrespect for his teaching which makes it useless to them. If there is fear that too much well-paid professional work will prevent efficiency in teaching, there is no great difficulty in applying a remedy.

One most important fact to be borne in mind is that efficient teachers cannot be obtained at such poor salaries as are now given. An efficient labourer is worthy of his hire; an inefficient labourer is not worthy of any hire, however small. Again, there is a necessity for three times as many teachers as are usually provided in England. The average man is in future to be really educated. This means very much more personal attention, and from thoughtful teachers. Is England prepared to face the problem of technical education in the only way which can lead to success, prepared to pay a proper price for the real article? If not, she must be prepared to see the average man remaining uneducated.

Advocacy of teaching of the kind that was given at Finsbury is often met by the opposition not only of pure mathematicians and academic teachers, but I am sorry to say also of engineers. The average engineer not merely looks askance at, he is really opposed to the college training of engineers, and I think, on the whole, that he has much justification for his views. University degrees in engineering science are often conferred upon students who follow an academic course, in which they learn little except how to pass examinations. The graduate of to-day, even, does not often possess the three powers to which I have referred. He is not fond of reading, and therefore he has no imagination, and the idea of an engineer without imagination is as absurd as Teufelsdröch's notion of a cast-iron king. He cannot really compute, in spite of all his mathematics, and he is absurdly innocent of the methods of the true student of Nature. This kind of labelled scientific engineer is being manufactured now in bulk because there is a money value attached to a degree. He is not an engineer in any sense of the word, and does not care for engineering, but he sometimes gets employment in technical colleges. He is said to teach when he is really only impressing upon deluded pupils the importance of formulæ, and that whatever is printed in books must be true. The real young engineer, caught in this eddy, will no doubt find his way out of it, for the healthy experience of the workshop will bring back his common-sense. For the average pupil of such graduates there is no help. If he enters works, he knows but little more than if he had gone direct from school. He is still without the three qualifications which are absolutely necessary for a young engineer. He is fairly certain to be a nuisance in the works and to try another profession at the end of his pupilage. But if it is his father's business he can make a show of knowing something about it, and he is usually called an engineer.

Standardisation in an industry usually means easier and cheaper and better manufacture, and a certain amount of it must be good even in engineering, but when we see a great deal of it we know that in that industry the true engineer is disliked. I consider that in the scholastic industry there has been far too much

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years, a mathematician (Osborne Reynolds or Dr. Hopkinson) who has common-sense notions about engineering things, or a fairly good engineer (Rankine or James Thomson) who has a common-sense command of mathematics, we have men who receive the greatest admiration from the engineering profession, and yet it seems to me that quite half of all the students leaving our technical colleges ought to be able to exercise these combined powers if mathematics were sensibly taught in school and college. We certainly have had enough of good mathematicians meddling with engineering theory and of engineers with no mathematics wasting their time in trying to add to our knowledge.

standardisation. Gymnasien and polytechnic systems are standardised in Germany, and there is a tendency to import them into England; but in my opinion we are very far indeed from knowing any system which deserves to be standardised, and the worst we can copy is what we find now in Germany and Switzerland. What we must strive for is the discovery of a British system suiting the British boy and man. The English boy may be called stupid so often that he actually believes himself to be stupid; but of one thing we may be sure, he will find in some way or other an escape from the stupefying kind of school work to which the German boy submits. And if it were possible to make the average English boy of nineteen pass such a silly school-leaving examination as the German boy,[1] and to pass through a polytechnic, I am quite sure that there would be little employment among common-sense English engineers for such a manufactured article. But is it possible that British boys could be manufactured into such obedient academic machines, without initiative or invention or individuality, by teachers who are none of them engineers? No, we must have a British system of education. We cannot go on much longer as we have done in the past without engineering education, and, furthermore, it must be such as to commend itself to employers. Of my Finsbury students I think I may say that not one failed to get into works on a two or three years' engagement, receiving some very small wage from the beginning, and without paying a premium. To obtain such employment was obviously one test of fitness to be an engineer, because experienced men thought it impossible. One test of the system was the greater ease with which new men obtained employment in shops which had already taken some of our students. It is certainly very difficult to convince an employer that a college man will not be a nuisance in the shops. In Germany and France, and to a less extent in America, there is among employers a belief in the value of technical education. In England there is still complete unbelief. I have known the subscribers of money to a large technical college in England (the members of its governing board) to laugh, all of them, at the idea that the college could be of any possible benefit to the industries of the town. They subscribed because just then there was a craze for technical education due to a recent panic. They were ignorant masters of works (sons of the men who had created the works), ignorant administrators of the college affairs, and ignorant critics of their mismanaged college. I feel sure that if the true meaning of technical education were understood, it would commend itself to Englishmen. Technical education is an education in the scientific and artistic principles which govern the ordinary operations in any industry. It is neither a science, nor an art, nor the teaching of a handicraft. It is that without which a master is an unskilled master; a foreman an unskilled foreman; a workman an unskilled workman; and a clerk or farmer an unskilled clerk or farmer. The cry for technical education is simply a protest against the existence of unskilled labour of all kinds.[2]

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[1] The following is, I understand, a stock question at certain gymnasien: 'Write out all the trigonometrical formulæ you know.' I asked my young informant, 'Well, how many did you write?' 'Sixty-two' was the answer. This young man informed me that a boy could not pass this examination unless he knew '*all* algebra and *all* trigonometry and *all* science.' Strassburg geese used to be fed in France; now they are fed in Germany. German education seems to be like smothering a fire with too much fuel or wet slack which has the appearance of fuel.

[2] I have pointed out how natural it is that business men should feel somewhat antagonistic to college training. Poorly paid unpractical teachers, with no ideas of their own, have in the past taught in the very stupidest way. They have called themselves 'scientific' and 'theoretical' till these words stink in the nostrils of an engineer. When I was an apprentice, and no doubt it is much the same now, if an apprentice was a poor workman with his hands he often took to some kind of study which he called the science of his trade. And in this way a pawkiness for science got to be the sign of a bad workman. But if workmen were so taught at school that they all really knew a little physical science, it would no longer be laughed at. When a civil or electrical engineer is unsuccessful because he has no business habits, he takes to calculation and the reading of so-called scientific books, because it is

To have any good general system the employers must co-operate. Much of the training is workshop practice, and it cannot be too often said that this is not to be given in any college. The workshop in a college serves a quite different purpose. Now how may the practice best be given? I must say that I like the Finsbury plan very much indeed, but there are others. When I attended this college in winter I was allowed to work in the Lagan Foundry in summer. In Japan the advanced students did the same thing; they had their winter courses at the college, and the summer was spent in the large Government workshops; the system worked very well indeed.[1] In Germany recently the great unions of manufacturers made facilities for giving a year of real factory work to the polytechnic students, but it seems to me that these men are much too old for entrance to works, and, besides, a year is too short a time if the finished product is to call itself a real engineer. Possibly the British solution may be quite different from any of these. A boy may enter works at fourteen on leaving a primary school or not later than sixteen on leaving a secondary school. In either case he must have the three powers to which I have already referred so often. It will be recognised as the duty of the owners of works to provide, either in one large works or near several works, in a well-equipped school following the Finsbury principle, all that training in the principles underlying the trade or profession which is necessary for the engineer.

No right-thinking engineer has been scared by the newspaper writers who tell us of our loss of supremacy in manufacture, but I think that every engineer sees the necessity for reform in many of our ways, and especially in this of education. People talk of the good done to our workmen's ideas by the strike of two years ago; it is to be hoped that the employers' ideas were also expanded by their having been forced to travel and to see that their shops were quite out of date.[2] In fact, we have all got to see that there is far too much unskilled labour among workmen and foremen and managers, and especially in owners. There may be some kinds of manufacture so standardised that everything goes like a wound-up clock, and no thought is needed anywhere; but certainly it is not in any branch of engineering. Many engineering things may be standardised, but not the engineer himself. Millions of money may build up trusts, but they will be wasted if the unskilled labour of mere clerks is expected to take the place of the thoughtful skilled labour of owners and managers. I go further, and say that no perfection in labour-saving tools will enable you to do without the skilled, educated, thoughtful, honest, faithful workman with brains. I laugh at the idea that any country has better workmen than ours, and I consider education of

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very easy to get up a reputation for science. The man is a bad engineer in spite of his science, but people get to think that he is an unpractical man because of his scientific knowledge. I do believe that the unbelief in technical education so very general has this kind of illogical foundation. Four hundred years ago if a layman could read or write he was probably a useless person who, because he could not do well otherwise, took to learning. What a man learnt was clumsily learnt; usually he learnt little with great labour and made no use of it; therefore reading and writing seemed useless. Now that everybody is compelled to read and write, it is not a usual thing to say that it hurts a man to have these powers.

[1] It was the idea of Principal Henry Dyer.

[2] Not only is there an enormous improvement in the use of limit-gauges and checking and tools, and the careful calculation of rates of doing work by various tools and general shop arrangement, but attention is being paid to the comfort of workmen. There are basins and towels, and hot and cold water for them to wash in. In the old days it would have been called faddy philanthropy. Now, owners of works who scorn all softness of heart provide perfect water-closets for their men; their workshops are kept at a uniform temperature; the evil effect of a bad draught in producing colds, or a bad light in hurting the eyes, is carefully considered. In some of these works it is actually possible for a workman or a member of his family to get a luxurious hot bath for a penny. Will this really pay? Some clever hard-headed men of my acquaintance say they already see that it does pay very well indeed.

our workmen[1] to be the corner-stone of prosperity in all engineering manufacture. It is from him in countless ways that all hints leading to great inventions come. New countries like America and Germany have their chance just now; they are starting, without having to 'scrap' any old machinery or old ideas, with the latest machinery and the latest ideas. For them also the time will come when their machines will be getting out-of-date and the cost of 'scrapping' will loom large in their eyes. In the meantime they have taught us lessons, and this greatest of all lessons—that unless we look ahead with much judgment, unless we take reasonable precautions, unless we pay some regard to the fact that the cleverest people in several nations are hungry for our trade and jealous of our supremacy, we may for a time lose a little of that supremacy. In the last twenty-three years I have written a good deal about the harm done to England by the general dislike that there is among all classes for any kind of education. I do not say that this dislike is greater than it used to be in England; I complain that it is about as great.[2] But I have never spoken of the decadence of England. It is only that we have been too confident that those manufactures and that commerce and that skill in engineering, for which Napoleon sneered at us, would remain with us for ever. Many writers have long been pointing out the consequences of neglecting education; prophesying those very losses of trade, that very failure of engineers to keep their houses in order, which now alarms all newspaper writers. Panics are ridiculous, but there is nothing ridiculous in showing that we can take a hint. We have had a very strong hint given us that we cannot for ever go on with absolutely no education in the scientific principles which underlie all engineering. There is another important thing to remember. Should foreigners get the notion that we are decaying, we shall no longer have our industries kept up by an influx of clever Uitlanders, and we are much too much in the habit of forgetting what we owe to foreigners, Fleming and German, Hollander, Huguenot, and Hebrew, for the development of our natural resources. Think of how much we sometimes owe to one foreigner like the late Sir William Siemens.

But I am going too far; there is after all not so very much of the foolishness of Ishbosheth among us, and I cannot help but feel hopeful as I think lovingly of what British engineers have done in the past. We who meet here have lived through the pioneering time of mechanical and electrical and various other kinds of engineering. Our days and nights have been delightful because we have had the feeling that we also were helping in the creation of a quite new thing never before known. It may be that our successors will have a better time, will see a more rapid development of some other applications of science. Who knows? In every laboratory of the world men are discovering more and more of Nature's secrets. The laboratory experiment of to-day gives rise to the engineering achievement of to-morrow. But I do say that, however great may be the growth of engineering, there can never be a time in the future history of the world, as there has never before been a time, when men will have more satisfaction in the growth of their profession than engineers have had during the reign of Queen Victoria.

And now I want to call your attention to a new phenomenon. Over and over again has attention been called to the fact that the engineer has created what is called 'modern civilisation,' has given luxuries of all kinds to the poorest people, has provided engines to do all the slave labour of the world, has given leisure and freedom from drudgery, and chances of refinement and high thought and high emotion to thousands instead of units. But it is doing things more striking still. Probably the most important of all things is that the yoke of superstitions of all kinds on the souls of men should be lifted. The study of natural science is alone able to do this, but education through natural science for the great mass of the people, even for the select few called the distinguished men of the country, has been quite impossible till recently. I say that it is to engineers that the world owes the possibility of this new study becoming general. In our country nearly all discoveries come from below. The leaders of science, the inventors, receive from a thousand obscure sources the germs of their great discoveries and inventions. When every unit of the population is familiar with scientific ideas our leaders will not only be more numerous, but they will be individually greater. And it is we, and not the schoolmasters, who are familiarising the people with a better knowledge of Nature. When men can hardly take a step without seeing steam engines and electro-motors and telegraphs and telephones and steamships, with drainage and water works, with railways and electric tramways and motor-cars; when every shop-window is filled with the products of engineering enterprise, it is getting rather difficult for people to have any belief in evil spirits and witchcraft.

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[1] The old appenticeship system of training men has broken down, and this is the cause of most of our industrial troubles. An apprenticeship system suited to modern conditions is described fully on pages 68–88 of *England's Neglect of Science.*

[2] *Loc. cit.*

All the heart-breaking preaching of enthusiasts in education would produce very little effect upon an old society like that of England if it were not for the engineer. He has produced peace. He is turning the brown desert lands of the earth into green pastures. He is producing that intense competition among nations which compels education. If England has always been the last to begin reform, she has always been the most thorough and steadfast of the nations on any reform when once she has started on it. Education, pedagogy, is a progressive science; and who am I that I should say that the system of education advocated by me is that which will be found best for England? In school education of the average boy or man England has as yet had practically no experience, for she has given no real thought to it. Yet when she does, I feel that although the Finsbury scheme for engineers may need great improvement, it contains the germ of that system which must be adopted by a race which has always learnt through trial and error, which has been led less by abstract principles or abstract methods of reasoning than any race known in history.

The following Paper was read:—

1. *Recent Progress in Large Gas Engines.* *By* HERBERT A. HUMPHREY, *A.M.Inst.C.E.*

The author said that the last few years had seen a development in large gas engines which has but few parallels in the history of engineering enterprise. Gas engines of 1,200 and 1,500 h.p. are already working, and others of 2,000 to 4,000 h.p. are being constructed. In the Paris Exhibition of 1900 the 600 h.p. Cockerill gas engine created much surprise, but now the makers have in hand an engine of 2,500 h.p., and are quite prepared to build a 5,000 h.p. gas engine.

In this country the first gas engines above 400 h.p. were started in 1900 and ran with Mond gas, but at the present time the two leading English manufacturers have delivered or have under construction fifty-one gas engines of between 200 and 1,000 h.p. Of these Messrs. Crossley Brothers, of Manchester, supply twenty-eight engines, having an aggregate of 8,300 h.p., or an average of 296 h.p. per engine, and the Premier Gas Engine Company, of Nottingham, supply twenty-three engines with a total of 9,300 h.p., giving an average of 404 h.p. per engine. These two makers collectively supply 17,600 h.p., and of this power 12,500 h.p. is for driving dynamos.

This is a striking proof of rapid progress, but we have to look abroad for the great achievements in this direction. Neglecting, throughout this paper, all engines below 200 h.p., we find that Messrs. Körting Bros. and their licensees have made or have under construction thirty-two gas engines with a total of 44,500 h.p., averaging 1,390 h.p. per engine. The Société Anonyme John Cockerill of Seraing and their licensees come next with fifty-nine engines, having an aggregate of 32,950 h.p.; so that the average size of the engines built by this firm is 558 h.p. The Gasmotoren Fabrik Deutz take the third place with fifty-one engines, developing collectively 20,655 h.p.; and are followed by the Deutsche Kraftgas Gesellschaft and licensees, working under the Oechelhaeuser patents, with engines numbering twenty-eight and giving 16,900 h.p.

Although America has lagged somewhat behind the Continent in adopting large gas engines, there is evidence that this state of affairs will not long continue. The Snow Steam Pump Works of Buffalo, New York, have only recently started the manufacture of gas engines, yet they have already put to successful work six gas engines of 1,000 h.p. each, and are now constructing two enormous gas-engine gas compressors of 4,000 h.p. each, the first to be running next November, and the second by January 1903. The Westinghouse Machine and Manufacturing Company, of Pittsburgh, have made gas engines of 1,500 h.p., and are prepared to build sizes up to 3,000 h.p., either horizontal or vertical.

Improvements in construction were then dealt with, the points touched upon being concerned respectively with the framework, the cylinder and piston, the valves, ignition apparatus, governing devices, and self-starting mechanism.

Types of engines were briefly considered with a view to show upon what lines the development is progressing, and to indicate the kind of machine which may be expected to prove the most successful gas engine in the future.

Some advances in the theory of the gas engine were mentioned. The last few years have shed some light on what takes place in a gas-engine cylinder, and the author referred to the questions of temperature gradients, the effect of increased specific heats of gases at high temperatures, and the effect of high pressures on the mode of heat transference to the cylinder walls. The heat efficiency of gas engines received attention, and some figures were given as to the relative efficiencies of gas and steam engines.

Gas Engines for Central Stations.—It is admitted that the future of gas engines for central-station purposes depends on the ability of gas engines to drive alternators in parallel. Numerous instances were given in which gas-driven alternators are regularly at work in parallel, giving good results. The permissible cyclic variation of gas engines intended for driving alternators was discussed, and other matters relating to successful parallel working were dealt with.

FRIDAY, SEPTEMBER 12.

The following Papers and Report were read:—

1. *Steam Turbines.* *By* HON. C. A. PARSONS, *F.R.S.*

2. *Report on the Resistance of Road Vehicles to Traction.* See Reports, p. 314.

3. *On Regular Undulations produced in a Road by the Use of Sledges.*

By VAUGHAN CORNISH, *D.Sc., F.G.S., F.C.S., F.R.G.S.*

On the steep road from the Saddlestone Slate Quarry, Coniston, Lancs, sledges are used to convey the slate down to the railway, the load for a sledge being half a ton. On the up journey the empty sledge is placed in the cart, to which on the down journey it acts as a drag, so that the sledges are only dragged in one direction, viz., downhill. The sledges produce undulations of a symmetrical and rounded form, resembling a curve of sines, in the road. The length of the sledge-runners is 4 feet 7 inches. The average length of the undulations from crest to crest was, in September 1901, 14 feet 8 inches, and in August 1902, 14 feet 9·4 inches, *i.e.* a little more than three times the length of the sledge. The average height from trough to crest of a series of seven ridges, measured in 1902, was 7·5 inches. Identical sledges are used on part of the road from Cove Quarry, on another side of the hill (the 'Old Man' of Coniston), which also produce undulations, the average length of which was 14 feet 9 inches. Sledges have been in use on the Saddlestone Quarry road for forty years, and it has not been found practicable to avoid the formation of these inconvenient undulations. From time to time the crests, which are said to become very hard and compact, are hacked up, and the material thrown into the troughs. Their formation is generally ascribed by those who use the road to initial inequalities (such as cross-channels caused by violent rains) of sufficient size to make the sledge pitch. Unequal hardness of different parts of the road has also been assigned as a cause for commencing that pitching motion which is obviously associated with the formation of the undulations.

When these conditions exist they undoubtedly tend to produce the effect; but the author has found, by experiment with a miniature sledge, that, when the detritus of the road consolidates readily under pressure, these undulations arise spontaneously by the action of a steadily moving sledge when furrowing a homogeneous and level road. The wedge of detritus pushed along in front of the prow of the sledge becomes compacted, the sledge surmounts it, rolling like a wheel, and the detritus remains behind, as an excrescence incorporated with the road. At the same time the sledge pitches, furrowing the road more deeply, accumulating detritus in front of it, which it finally surmounts (with the rolling movement which assists to compress, bind, and consolidate the material) building up the next crest.

The conversion of the plane surface to a strongly undulating surface of definite wave length, in the author's experiments about 3½ times the length of the sledge, proceeded very rapidly when the material (coarse river sand by the shore of Coniston Water) was of the right degree of dampness. The (horizontal) track was free from inequalities or obstructions, and the sledge was drawn steadily *and slowly*.

Corresponding undulations sometimes produced by sledge-driving on snow-covered roads are familiar in Canada, where they are called *cahots* (jolts). The author saw these in and near Montreal in the winter 1900–1901. They averaged 13 feet in length from crest to crest, and 8 inches appeared to be a not uncommon amplitude. The length of the sledge-runners varied, but 5 to 6 feet seemed to be a common size. The author came to the conclusion that for the marked development of *cahots* the snow should be in the state to bind under the pressure of the sledge when it rolls over a prominence. The dry snow in zero weather at Winnipeg did not show the same tendency to go into *cahots*.

The author has investigated many cases of undulating surfaces spontaneously produced by the passage of a *fluid* (air or water) over granular materials. The above observations appear to extend the range of this class of phenomena.

4. *A New Elastic Vehicle Wheel.* *By* J. Brown, *F.R.S.*

In previously designed vehicle wheels having springs inserted between hub and rim, such springs, if rigidly fixed at their ends, are soon broken off at these points of attachment owing to the bending due to the continual displacement of the hub relatively to the rim during the revolution of the wheel.

If springs be attached through jointed connections to rim and hub, the action of such joints involves continual loss of power by friction in the joints as the wheel revolves.

In the wheel shown no joints are used, and the spring spokes are attached rigidly to hub and rim, but the tendency to fracture at the points of attachment is overcome in spreading the breaking stress over a foot or more of the ends of the spring by giving the ends of the steel strip from which the spring is made a taper form, gradually increasing in thickness towards the ends. The spring spokes are crossed alternately between hub and rim to give sideway stability. The outer ends are bolted to a casting attached to inner side of rim; the inner ends to a specially made hub so formed that by means of a taper key passing through a slot in the tail of the spring its tension can be adjusted so as to keep the rim true. The whole set of springs are then clipped fast by rings bolted on the faces of the hub. The wheel stood well a test at considerable speed on rough roads as a driver, and carrying a load of 11 cwt.

5. *An All-stations Express Train.* *By* J. Brown, *F.R.S.*

The working model exhibited illustrated the automatic working, by means of appropriate self-acting switches and couplings, of the scheme for an electric railway described in the 'Journal of the Institute of Electrical Engineers,' vol. xxx., part 148 (1901), together with a newly added protective signalling device indicating to the driver in a car following another car, which it is about to pick up, the distance between such cars. This consists of a resistance fixed along the side of the track in contact with brushes or sliders on the cars. The brush on the car in advance is joined, say, to the positive of the main electric supply; that on the following car to the negative. The current consequently flowing through the resistance, being inversely proportional to the distance between the cars, may indicate this distance on appropriate instruments under the driver's eye in each car.

6. *The Rainfall of Ireland.*

By Hugh Robert Mill, *D.Sc., LL.D., F.R.S.E.*

In order to determine the true mean annual rainfall of any region it is necessary to have uniform, continuous, and prolonged observations at a large number of well-distributed stations.

It is now possible for the first time to give a fairly satisfactory account of Irish rainfall, though the observing stations at work are only one for every 170 square miles as compared with one for every twenty square miles in England. The number of stations in Ireland has increased from 83 in 1874 to 190 in 1901, an increase of 140 per cent.; while the number of stations in England and Wales increased only by 120 per cent., and in Scotland only by 32 per cent., in the same period. In 1874 there was not a single record of rainfall from the counties of Clare, Kildare, Leitrim, Limerick, Longford, or Monaghan; now there is at least one rain record from every county. The number of stations is still far too small, especially in Connaught; and after the stimulus of the British Association in Belfast produced its effect in 1875 the number in Ulster has ceased to grow:—

Province	No. of Rain Stations in 1874	No. in 1875	No. in 1901
Ulster	30	55	56
Connaught	10	15	22
Leinster	26	31	62
Munster	17	28	50
Ireland	83	129	190

While 1,400 additional stations would be necessary to place Ireland on the same footing as an equal area of England, only 185 additional observers are required to give the same number of rain-gauges per thousand of population.

Perfect records for the ten years 1890–99 exist for 108 stations in Ireland, and by computation thirty-one additional records can be made available. Of these twenty-one records are perfect for the thirty years 1870–99, and fifty-six records of somewhat shorter duration can be computed with reasonable accuracy. The distribution is not satisfactory, the western half of the country and all the mountainous districts being very poorly represented. Maps have been constructed, however, which give a better representation of Irish rainfall than anything previously compiled.

The map for the thirty years 1870–99 may be taken as showing the true mean fall so far as the limited number of stations makes it possible to do so. There are only three small areas with a fall exceeding 50 inches per annum in the west of Kerry, of Mayo and Galway, and of Donegal respectively. Possibly some parts of the eastern mountains may also have a fall exceeding 50 inches. More than inches falls over the whole of Ireland west of the Foyle and the Shannon, and the west and south of a line drawn from Limerick through Mallow to Clonmel, hence a narrow belt, equally wet, runs north-eastward through the counties of aterford, Wexford, and Wicklow. Two small areas with more than 40 inches cur in the south-east of Co. Down and the east of Co. Antrim. All the rest of eland has between 30 and 40 inches of rain, except parts of Co. Dublin and o. Meath, where the fall averages less than 30 inches. The following table gives rough approximation to the areas of the different zones of rainfall:—

Under 30 inches (average 29 in.) . . .	700	square miles.
From 30 to 40 inches (average 35·5 in.) .	13,200	"
From 40 to 50 inches (average 44 in.) . .	13,500	"
Above 50 inches (average 60 in.) . . .	5,200	"
Ireland . . .	32,600	

his gives an average of 42 inches for the whole country; a figure which, lthough by no means certain, is probably not very far from the truth.

The variations of rainfall in Ireland are less than those in England. Thus for he ten years 1890–99 the rainfall over Ireland was only 2 per cent. below the hirty years' average; that over England and Wales showed a deficiency of 7 per ent.[1] The average rainfall of the ten years was practically the same as that of he thirty years in central Ireland, a trifle above the average in the north-west, nd a little below the average round the north, east, and south coasts.

Rainfall Averages for Thirty Years, 1870–99.

Place	1870–79	1880–89	1890–99	1870–99
	in.	in.	in.	in.
Portlaw, Mayfield, Co. Waterford . . .	41·65	43·31	42·18	42·38
Glenam, Clonmel, " . . .	43·47	42·15	40·89	42·17
New Ross, Longraigue, Co. Wexford . . .	43·57	39·29	38·75	40·54
Enniscorthy, Ballyhyland, " . . .	44·36	42·80	41·45	42·87
Gorey, Courtown House, " . . .	38·14	35·39	33·62	35·72
Inistioge, Woodstock, Co. Kilkenny . . .	46·64	41·67	38·50	42·27
Bray, Fassaroe, Co. Wicklow	38·70	43·28	39·68	40·55
Carlow, Browne's Hill, Co. Carlow . . .	36·09	33·59	33·65	34·44
Dublin, FitzWilliam Square, Co. Dublin . .	28·47	27·47	27·30	27·75
Athlone, Twyford, Co. West Meath . . .	40·47	38·97	35·83	38·42
Ballinasloe, Co. Galway	38·89	35·66	36·58	37·04
Tuam, Gardenfield (6 ft.), Co. Galway . .	38·43	42·76	41·85	41·01
Belturbet, Redhills, Co. Cavan	36·57	34·57	34·42	35·19
Armagh, Observatory, Co. Armagh . . .	30·95	32·16	30·97	31·36
Seaforde, Co. Down	41·67	37·89	36·27	38·61
Banbridge, Milltown, Co. Down . . .	32·75	31·44	30·23	31·47
Waringstown, "	34·03	33·02	34·14	33·73
Belfast, Queen's College, Co. Antrim . . .	34·92	32·77	32·00	33·23
" Antrim Road, " . . .	33·86	34·57	35·28	34·57
Omagh, Edenfel, Co. Tyrone	37·25	36·63	39·66	37·85

7. *Water Power in Ireland.* *By* F. J. DICK.

8. *A Direct Reducing Levelling Staff.*
By G. W. HERDMAN, *B.Sc.*

The object of this staff is to lessen the arithmetic which is always necessary to obtain from the observation through the level telescope the actual height above datum (or 'reduced level') of the spot where the staff is held.

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[1] See *British Rainfall*, 1901, p. 24.

The staff may be any number of feet in length, and may be graduated according to any pattern which the user finds convenient. It differs essentially from the ordinary levelling staff in having a shoe which slides on the staff at the end with the maximum graduations, and which can be extended and fixed at any particular hundredth of a foot so as to lengthen the staff by the amount of that extension.

The method of employing it is as follows:—

Having set up the level, the height of the instrument or 'collimation level' is obtained, as usual, by adding to the value of the 'bench mark' on which the staff is held the reading seen on the staff. The shoe is now extended to the amount of the decimals in the collimation level, and in the field-book, beneath the collimation level, is written the 'datum level,' which is the total length of the extended staff less than the collimation level. The 'datum level' consequently is a whole number without decimals. All other observations from this position of the level are now taken with the staff inverted, *i.e.*, the shoe on the ground, and the reduced level is obtained by adding the reading to the datum level.

The amount to which the shoe is extended only has to be altered when the collimation level is altered, *i.e.*, when the instrument's position has been altered. The booking as reduced levels of a large number of observations from one position of the level is extremely simple and rapid.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Papers were read:—

1. *The Future of the Telephone in the United Kingdom.*
By J. E. KINGSBURY.

2. *A New Magnetic Testing Instrument.* *By* F. HOLDEN.

3. *The Electrical Conductivity of certain Aluminium Alloys as affected by Exposure to London Atmosphere.*[1] *By* Professor ERNEST WILSON.

This paper deals with the effect upon electrical conductivity of exposing light aluminium alloys to London atmosphere. The author pointed out that if commercially pure aluminium be alloyed with a small percentage of copper for the purpose of increasing its tensile strength exposure diminishes electric conductivity, possibly by electrolytic action pitting the surface. If, in addition to the copper, a small percentage of nickel be added, no such effect occurs, and the tensile strength is increased. The discovery that metals which alloyed alone with aluminium may produce unfavourable effects, but in combination prove beneficial, may have practical importance in other than electrical branches of engineering. The physical properties of aluminium alloys are still little understood, and the subject is of great interest to engineers in general.

4. *Some Electrical Instruments.* *By* M. B. FIELD.

Four instruments were exhibited and briefly described. The first was a voltmeter for a three-wire circuit which was compensated for the voltage drop in a triple concentric cable, of which the outers had a cross-section of 0·5 square inch and the neutral 0·25 square inch. The feeder was one mile in length.

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[1] See the *Electrician*, September 19, 1902.

The second instrument was intended for determinations of amperes, volts, watts, and power factor. It was constructed on the hot-wire principle, and was intended for use in test-rooms, workshops, &c. The various determinations were made by taking readings with a plug attached to the instrument in different plug-holes, two readings being necessary for the determination of watts.

The third instrument was styled a 'fault indicator,' being designed principally for use on tramway circuits. The circuit-breakers protecting tramway feeders often open for unknown causes: sometimes it may be due to faults occurring, sometimes merely temporary overload. Usually the circuit-breakers are closed again without further precaution. This is obviously an unsatisfactory proceeding. The fault indicator showed whether the line was 'clear' or 'blocked' by measuring its resistance. It was arranged on the principle of a bridge: if the resistance was below a certain amount the pointer of the indicator went hard over to the left, indicating 'line blocked'; if above a certain limit, hard over to the right, indicating 'line clear.'

The fourth instrument was a synchronising switch and voltmeter.

The switch was arranged so that with a single setting it—

(1) put pilot synchronising lamps into the circuit, which lamps were situated near the engine of the incoming alternator for the driver's benefit;

(2) put synchronising lamps into circuit on the panel of the incoming alternator;

(3) put a synchronising voltmeter in circuit;

(4) put a special voltmeter into circuit with a double winding, each winding actuating an independent pointer.

The two pointers, however, moved over the same dial, and were arranged so that if they were indicating equal voltage they together formed a radial line across the dial; if unequal, a broken line. The one winding was connected to the incoming alternator, the other to the 'bus bars. The double voltmeter and the synchronising voltmeter were mounted on the same swinging bracket. With the arrangement described the ordinary general arrangement of the switchboard could be simplified, and the process of synchronising facilitated.

5. *The Science of the Workshop.* *By* W. TAYLOR.

6. *The Importance of Minor Details in Engineering Work.*
By M. HOLROYD SMITH.

7. *On the Specific Utilisation of Materials in Dynamo Construction.*
By Professor S. P. THOMPSON, *F.R.S.*

8. *A new Flashing Lighthouse Light without Intervals of Darkness.*
By J. R. WIGHAM.

9. *A Joint Discussion with Section L on the Training of Engineers.*

TUESDAY, SEPTEMBER 16.

The following Report and Papers were read:—

1. *Report on the Small Screw Gauge.*—See Reports, p. 350.

2 *The Smokeless Combustion of Bituminous Fuel.*
By W. H. BOOTH, *M.Am.Soc.C.E.*

The author points out that although engineers are taught the conditions necessary to combustion, they do not put them into practice, and the modern boiler is fixed in the most primitive manner.

Certain fuels burn without smoke, and may be burned directly below heat-absorbing surface. This cannot be done smokelessly with hydrocarbons, because of the greater avidity of hydrogen than of carbon for oxygen, and the necessity of preserving a high temperature for burning hydrocarbon gas.

The difference between long and short flaming coal is pointed out and the effects noted.

The effect of refractory furnaces is discussed. The refrigerating effect of volatilising solid hydrocarbons is discussed in its effect on the distribution of temperature in a furnace, and the production of heat at and beyond the grate surface. Though less heat is produced at the grate surface, the total heat-production of bituminous coal is eventually secured if suitable furnace arrangements are provided for the purpose.

The faults of everyday boiler-settings are pointed out in respect of various types of boilers, and the bad effect of cold-water pipes in the path of the furnace gases is referred to. Though very bad as a smoke producer, the common form of water-tube boiler can easily be set so as not to produce smoke. The furnaces must be so arranged that all the gaseous products of the furnace are swept together with all the admitted air, and are not cooled down until sufficiently burned to admit of being used. For this purpose furnace linings must be non-heat absorbent.

Small-tube boilers are condemned in their more common forms, and the arrangement of the refractory furnace of the Weir boiler pointed out as affording economical and smokeless combustion.

The locomotive is also instanced as an example of how partial recognition of the correct principles has been fairly successful.

Some of the attempts to secure smokeless combustion are discussed, and the conviction expressed that there is nothing in smoke prevention to justify the assertion so often made that it is economically impossible.

The final conclusion is that smokeless combustion of bituminous coal is as easy and certain as the reverse method.

3. *The Prevention of Smoke.* *By* J. S. RAYWORTH.

4. *The Solignac Boiler.* *By* W. H. BOOTH.

5. *The Making of a Dynamo.* *By* H. A. MAVOR.

6. *Experiences with the Infantry Range-finder in the South African War.*
By Professor G. FORBES, *F.R.S.*

7. *A Preliminary Note on Gas-engine Explosions.*[1] *By* H. E. WIMPERIS.

In this note the writer refers to a previous paper published in the columns of *Engineering* (June 27 and August 1, 1902) in which the thermodynamic properties of gaseous mixtures during explosion were investigated in the light of the results btained by the Gas-engine Research Committee of the Institution of Mechanical Engineers. A linear relation to connect specific heat and temperature was mployed, and the present case is a consideration, on somewhat similar lines, of he results obtained in the classical experiments carried out by Dugald Clerk. It is shown that with variable specific heat constants and cooling corrections based on experimental data it is possible to account for the whole of the heat liberated during explosive combination, and that it is unnecessary to assume the existence of any after-burning.

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[1] Published *in extenso* in *Engineering*, October 10, 1902, and in the *Engineer*, October 10, 1902.

8. *A Note on Gas-engine Explosions.* *By* Professor J. Perry, *F.R.S.*

9. *The Direction and Velocity of Material-bearing Ocean Currents, with Description of an Apparatus recently designed for Estimating the same.* *By* R. G. Allanson-Winn, *B.A.*, *M.Inst.C.E.I.*

It appears that our present knowledge with respect to the action of bottom currents is very incomplete; and that experiments, conducted with great care over lengthy periods, are necessary in order to establish certain data.

A large number of experiments at many places would involve the expenditure of considerable sums annually, but the author is convinced that such an outlay would be by no means thrown away; and with the view of making a start with actual experiments he has designed a simple form of current indicator by means of which the direction and velocity of bottom currents may be very approximately arrived at.

The instrument exhibited is of simple construction, and not liable to get out of order. It consists of a very heavily weighted vertical bar on which rotates a free vane capable of being clamped the moment the apparatus leaves the bottom on which it is resting during the registration of direction and velocity. A compass is attached, and this is also clamped at the same moment; so that the observer, on pulling up the instrument, has been enabled to take the depth of water and the direction of the bottom current. The measurement of the velocity is arrived at by the attachment to the vane of a current meter of approved pattern, such as Revey's screw or B. T. Moore's.[1]

This meter may be also set free on the instrument touching the bottom, and clamped the moment it leaves the bottom.

In order to guard against disturbances such as seaweed, jelly-fish, &c., &c., the whole apparatus can be sunk in a cylindrical wire-netting case. Even this protection is not sufficient; so it is very advisable to take several soundings, and then take the mean of these.

The author feels that a great deal depends upon the simplicity of the working parts of an instrument for sea observations, very delicate machines being liable to be thrown out of gear by unavoidable rough usage and the action of salt water.

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[1] *Proc. Inst.C.E.*, xlv. 220.

SECTION H.—ANTHROPOLOGY.

PRESIDENT OF THE SECTION—A. C. HADDON, M.A., Sc.D., F.R.S., M.R.I.A.

THURSDAY, SEPTEMBER 11.

The President delivered the following address:—

So much has been written of late on totemism that I feel some diffidence in burdening still further the literature of the subject. But I may plead a slight claim on your attention, as I happen to be an unworthy member of the Crocodile kin of the Western tribe of Torres Straits, and I have been recognised as such in another island than the one where I changed names with Maino, the chief of Tutu, and thereby became a member of his kin.

I do not intend to discuss the many theories about totemism, as this would occupy too much time; nor can I profess to be able to throw much light upon the problems connected with it; but I chiefly desire to place before you the main issues in as clear a manner as may be, and I venture to offer for your consideration one way in and some ways out of totemism.

A few years ago M. Marillier wrote[1] that 'totemism is one of the rare forms of culture: it is incapable of evolution and transformation, and is intelligible only in its relations with certain types of social organisation. When these disappear it also disappears. Totemism in its complete development is antagonistic alike to transformation or progress.' In due course I shall describe how one people at least is emerging from totemism. At the outset I wish it to be distinctly understood that I do not regard this as the only way out; doubtless there have been several transformations, but a record of what appears to be taking place appeals more to most students than a guess as to what may have happened.

What is most needed at the present time is fresh investigation in the field. Those who are familiar with the literature of the subject are only too well aware of the imperfection of the available records. There are several reasons which account for this. Some of the customs and beliefs associated with totemism have a sacred significance, and the average savage is too reverent to speak lightly of what touches him so deeply. Natives cannot explain their mysteries any more than the adherents of more civilised religions can fully explain theirs. Further, they particularly dislike the unsympathetic attitude of most inquirers, and nothing silences a native more effectually than the fear of ridicule.

Language is another difficulty. Even supposing the white man has acquired the language, the vocabulary of the native is not sufficiently full or precise to explain those distinctions which appeal to us, but which are immaterial to him.

Granting the willingness of the native to communicate his ideas, and that the hindrance of language has been overcome, there remains the difficulty of the native understanding what it is the white man wishes to learn. If there is a practically insuperable difficulty in the investigator putting himself into the mental attitude of the savage, there is also the reciprocal source of error.

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[1] *Rev. de l'Hist. des Religions*, xxxvi. 1897, pp. 368, 369.

'Oh, East is East, and West is West,
And never the twain shall meet.'

If Kipling is right for the civilised Oriental, how about those of lower stages of culture and more primitive modes of thought?

We must not overlook the fact that the majority of white men who mix with primitive folk are either untrained observers or their training is such that it renders them yet more unsympathetic—one might say antagonistic—to the native point of view. The ignorance and prejudice of the white man are great hindrances to the understanding of native thought.

When students at home sift, tabulate, and compare the available records, they get a wider view of the problems concerned than the investigator in the field is apt to attain. Generalisations and suggestions crystallise out which may or may not be true, but which require further evidence to test them. So the student asks for fresh observations and sends the investigator back to his field.

The term 'totemic' has been used to cover so many customs and beliefs that it is necessary to define the connotation which is here employed.

It appears from Major J. W. Powell's recent account of totemism[1] that the Algonkin use of the term 'totem' is so wide as to include the representation of the animal that is honoured (but he does not state that the animal itself is called a totem), the clay with which the person was painted, the name of the clan,[2] and that of the gens,[3] the tribal name, the names of shamanistic societies, the new name assumed at puberty, as well as the name of the object from which the individual is named. He distinctly states, 'We use the term "totemism" to signify the system and doctrine of naming.' I must confess to feeling a little bewildered by this terminology, and I venture to think it will not prove of much service in advancing our knowledge. It looks as if there had been some misunderstanding, or that the Algonkins employed the word 'totem' to cover several different ideas because they had not definite terms with which to express them. Major Powell's definitions practically exclude those cults which are practised in various parts of the world, and which by the common consent of other writers are described as totemic.

Professor E. B. Tylor has given[4] the following clear exposition of his interpretation of the American evidence: 'It is a pity that the word "totem" came over to Europe from the Ojibwas through an English interpreter who was so ignorant as to confuse it with the Indian hunter's patron genius, his *manitu*, or "medicine." The one is no more like the other than a coat of arms is like a saint's picture. Those who knew the Algonkin tribes better made it clear that totems were the animal signs, or, as it were, crests, distinguishing exogamous clans; that is, clans bound to marry out of, not into, their own clan. But the original sin of the mistake of Long the interpreter has held on ever since, bringing the intelligible institution of the totem clan into such confusion that it has become possible to write about "sex totems" and "individual totems," each of which terms is a self-contradiction. . . . Totems are the signs of intermarrying clans.'

A reviewer in 'L'Année Sociologique,' ii. 1899, says (p. 202): 'One must avoid giving to a genus the name of a species. It will be said these are merely verbal quibbles; but does not the progress of a science consist in the improvement of its nomenclature and in the classification of its concepts?'

Totemism, as Dr. Frazer and I understand it, in its fully developed condition implies the division of a people into several totem kins (or, as they are usually termed, totem clans), each of which has one, or sometimes more than one, totem. The totem is usually a species of animal, sometimes a species of plant, occasionally a natural object or phenomenon, very rarely a manufactured object. Totemism also involves the rule of exogamy, forbidding marriage within the kin, and necessitating intermarriage between the kins. It is essentially connected with the matriarchal stage of culture (mother-right), though it passes over into the patriarchal stage (father-right). The totems are regarded as kinsfolk and protectors or benefactors of the kinsmen, who respect them and abstain from killing and eating them. There is thus a recognition of mutual rights and obligations between the members of the kin and their totem. The totem is the crest, or symbol, of the kin.

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[1] *Man*, 1902, No. 75.

[2] A group that reckons descent only through the mother.

[3] A group that reckons descent only through the father.

[4] *Man*, 1902, No. 1; cf. *Journ. Anthrop. Inst.*, xxviii. 1898, p. 138.

Sometimes all the kins are classified into two or more groups; for example, in Mabuiag, in Torres Straits, there is a dual grouping of the kins, the totems of which are respectively land and water animals; and in speaking of the latter group my informant volunteered the remark, 'They all belong to the water; they are all friends.' On the mainland of New Guinea also I found that one group of the totems 'stop ashore,' while the other 'stop in water.' When no member of a group of kins in a community can marry another member of that same group, that group is termed a phratry. An Australian tribe is generally divided into two exogamous phratries.

North America is the home of the term 'totem,' and though typical totemism does occur there, it is often modified by other customs. In Australia we find true totemism rampant, and it occurs in Africa, where also it is subject to much modification. Quite recently the Rev. J. Roscoe has published an important paper[1] on the Baganda, in which he describes a perfectly typical case of totemism. Among the Baganda there are a number of kins, each of which has a totem, *muziro*. The kin, *kika*, is called after its totem; no member of a kin may kill or eat his totem, though one of another kin may do so with impunity. No one mentions his totem. Old people affirm their fathers found some things injurious to them, either as food or to their personal safety, and made their children promise not to kill or eat that particular thing. No man may marry into his mother's kin, because all the members of it are looked upon as sisters of his mother; nor may he marry into his father's kin except in the case of two very large kins. In Uganda, royalty follows the totem of the mother, whilst the common people follow the paternal totem. Each kin has its own special part of the country where the dead are always buried. For sympathy or assistance the member of a kin always turns to his particular kin. From what Mr. Roscoe says about the married women of the Green Locust kin, it is evident that the magical aspect of totemism is present, as it is in Australia and Torres Straits. The Baganda are thus a true totemic people who are in an interesting transitional condition between matriarchy and patriarchy. Totemic practices also occur in various parts of Asia.

To put the matter briefly, totemism consists of the following five elements:—

1. Social organisation with totem kinsmen and totem symbols.
2. Reciprocal responsibilities between the kin and the totem.
3. Magical increase[2] or repression of the totem by the kinsmen.
4. Social duties of the kinsmen.
5. Myths of explanation.

Totemism is only one of several animal cults, and it is now necessary to consider certain cults that have been termed totemic before I proceed with the main object of this Address.

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[1] *Journ. Anthrop. Inst.*, xxxii. 1902, p. 25.

[2] The first intimation of this aspect of totemism is entirely due to the researches of Messrs. Spencer and Gillen (*The Native Tribes of Central Australia*, 1899). Dr. J. G. Frazer, appreciating the value of these observations, extended the conception to totemism generally, *Journ. Anthrop. Inst.*, xxviii. 1899, p. 285, read December 14, 1898; the *Fortnightly Review*, April 1899, pp. 664, 665; *cf.* also 'Israel and Totemism,' by S. A. Cook, *Jewish Quart. Review*, April 1902, pp. 25, 26 of reprint.

Manitu (Guardian Spirit).

Very widely spread in North America was the belief in guardian spirits, which appeared to young men in visions after prayer and fasting. It then became the duty of the youth to seek until he should find the animal he had seen in his trance; when he found it, he must slay and preserve some part of it. In cases when the vision had been of no concrete form, a symbol was taken to represent it: this memento was ever after to be the sign of his vision, the most sacred thing he could ever possess, for by it his natural powers were so to be reinforced as to give him success as a hunter, victory as a warrior, and even power to see into the future.

The guardian spirit was obtained in various ways by different American tribes, but the dream apparition was the most widely spread. Dr. Frazer[1] calls it 'individual totem'; Miss Fletcher speaks of the object dreamed of (the *wahube* of the Omaha) as the 'personal totem' or simply as the 'totem'; it is termed by the Algonkin *manitu*, by the Huron *okki*, by the Salish Indians *sulia*, and *nagual* in Mexico. Perhaps it would be best to adopt either *wahube* or *manitu* to express the guardian spirit.

Miss Alice C. Fletcher finds that among the Omaha[2] those who have received similar visions, that is, those who have the same *wahube*, formed brotherhoods which gradually developed a classified membership with initiatory rites and other rituals. These religious societies acquired great power; still later, according to this observer, an artificial social structure, the 'gens,' was organised on the lines of the earlier religious societies. Each 'gens' had its particular name, which referred directly or symbolically to its totem, and its members practised exogamy and traced their descent only through the father. 'As totems could be obtained in but one way—through the rite of vision—the totem of a "gens" must have come into existence in that manner, and must have represented the manifestation of an ancestor's vision, that of a man whose ability and opportunity served to make him the founder of a family.' Mr. C. Hill-Tout,[3] in discussing the origin of the totemism of the aborigines of British Columbia, states:—'There is little room for doubt that our clan totems are a development of the personal or individual totem or tutelar spirit, as this is in turn a development of an earlier fetishism.'

Dr. F. Boas points out[4] that the tribes of the northern portion of the North Pacific group of peoples, such as the Tlingit, Haida, and Tsimshian, have a maternal organisation with animal totems: the clans bear the names of their respective totems and are exogamous. The central tribes, particularly the Kwakiutl, show a peculiar transitional stage. The southern tribes have a purely paternal organisation, and their groups are simple village communities which are often exogamic.

Dr. Boas distinctly asserts[5] that 'the natives do not consider themselves descendants of the totems; all endeavours to obtain information regarding the supposed origin of the relation between man and animal invariably led to the telling of a myth, in which it is stated how a certain ancestor of the clan in question obtained his totem. . . . It is evident that legends of this character correspond almost exactly to the tales of the acquisition of manitows among the eastern Indians, and they are evidence that the totem of this group of tribes is in the main the hereditary manitow of a family.[6] This analogy becomes still clearer when we consider that each man among these tribes acquires a guardian spirit, but that he can acquire only such as belong to his clan. Thus a person may have the general crest of his clan, and besides use as his personal crest such guardian spirits as he has acquired. This accounts partly for the great multiplicity of combinations of crests on the carvings of these people.'

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[1] *Totemism*, 1887, pp. 2, 53.

[2] 'The Import of the Totem,' *Proc. Amer. Assoc. Adv. Sci.*, Detroit Meeting, 1897, pp. 325 ff.

[3] *Trans. Roy. Soc. Canada* (2nd ser.), vii., sect. 2, 1901, p. 6.

[4] *Report U.S. Nat. Mus.*, 1895 (1897), pp. 322, 323, 334.

[5] *L.c.*, p. 323.

[6] But Mr. E. S. Hartland points out (*Folk-lore*, xi. 1900, p. 61) that we have clear evidence from the legends of the descent at all events of some of the clans from non-human ancestors; and Mr. Hill-Tout says: 'Among the Salish tribes it is uniformly believed that in the early days, before the time of the tribal heroes or great transformers, the beings who then inhabited the world partook of the character of both men and animals assuming the form of either apparently at will.'

Throughout a considerable portion of North America there appears to be a mixture of variously developed cults of the totem and of the *manitu*. It is not perhaps possible at present to dogmatise as to the relative chronology of these two cults. Personally I am in favour of the superior antiquity of the totem cult, as the conception of an individual spirit-helper appears to me to be of a higher grade than the ideas generally expressed by purely totemic peoples, or what may be gathered by implication from a study of their ceremonies.

The social organisation appears to be very weak in some Californian tribes; our knowledge of the Seri in this respect is very meagre, but Dr. Dixon definitely denies[1] the existence of totemic grouping among the Maidu.

Accepting then for the present the priority of the totem cult, we find a substratum of totemism underlying many of the social organisations in North America. Religious societies are a noticeable feature of the social life of North-west America; those societies have the guardian spirit (*manitu*) as their central idea, but it appears as if the organisation is rooted in a clan[2] system which has been smothered and virtually destroyed by the parasitic growth. The problems to be solved in North-west America are very complicated, and we must await with patience further researches. It is perfectly evident from the researches of Boas, Nelson, Hill-Tout, and others that comparatively recent great changes have taken place. Dr. Boas indeed states that 'the present system of tribes and clans (of the Kwakiutl) is of recent growth and has undergone considerable changes.'[3] An interesting illustration of this is found in the alteration in the organisation of the (Kwakiutl) tribe during the season of the winter ceremonial. 'During this period the place of the clans is taken by a number of societies, namely, the groups of all those individuals upon whom the same or almost the same power or secret has been bestowed by one of the spirits.'[4] The characteristic North American idea of the acquisition of the *manitu* was evidently also fundamental among the Kwakiutl, as all their tales refer to it, and the whole winter ceremonial is based on it.

I agree in the main with Mr. Hartland[5] in thinking that, 'whether or no totemism was anciently a part of the tribal organisation, the *manitu* conception is of modern date. It is part of the individualism which is tending, not among these tribes only, to obscure the older communistic traditions.'

Nyarong.

Allied to the *manitu* of North America is the *nyarong*, or spirit helper, of the Iban (Sea Dayaks) of Sarawak. The Iban believe that the spirit of some ancestor or dead relative may come to them in a dream, and this *nyarong* becomes the special protector of the individual. An Iban youth will often retire to some lonely spot or mountain-top and live for days on a very restricted diet in his anxiety to obtain a vision. This custom is called *mampok*. On the following day the dreamer searches for the outward and visible form of the *nyarong*, which may be anything from a curious natural object to some one animal. In such cases the *nyarong* hardly differs from a fetish. In other cases, as the man is unable to distinguish the particular animal which he believes to be animated by his *nyarong*, he extends his regard and gratitude to the whole species. In some instances all the members of a man's family and all his immediate descendants, and if he be a chief all the members of the community over which he rules, may come to share the benefits conferred by the *nyarong* and pay respect to the species of animal in one individual of which it is supposed to reside. 'In such cases,' Drs. Hose and

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[1] *Bull. Amer. Mus. Nat. Hist.*, xvii., pt. 2, 1902, p. 35.

[2] Matriarchal totemic kin.

[3] *L.c.*, p. 333.

[4] *L.c.*, p. 418.

[5] *Folk-lore*, xi. p. 68.

McDougall remark,[1] 'the species approaches very closely the clan totem in some of its varieties.' Here we have a parallel to the North American custom, but the later stages are not carried as far.

Personally I concur in the opinion expressed by Drs. Hose and McDougall that there is no proof that the peculiar regard paid in Sarawak to animals, the sacrifice of animals to gods or spirits, the ceremonial use of the blood of these sacrificed animals are survivals of a fully developed system of totem worship now fallen into decay. It is very significant that the magical and social aspects of totemism are entirely lacking.

Those who have read Miss Alice Fletcher's sympathetic account of 'The Import of the Totem'[2] can scarcely fail to recognise that the moral support due to a belief in the guidance and protection of a *wahube* ('personal totem') is of great importance to the individual, and would nerve him in difficulty and danger, and thus proving a very present help in time of need, it would surely justify its existence in a most practical manner, and consequently be of real utility in the struggle for existence—a struggle which in man has a psychical as well as a material aspect.

The advantages of totemism are many, but most of them are social and benefit the special groups or the community at large. The hold that the *manitu* has on the individual consists in its personal relation: the man feels that he himself is helped, and I suspect this is the main reason why it supplants totemism. I believe Mr. Lang some years ago suggested the term *manituism* for this cult. If this name be not accepted I venture to propose the revival of the word 'daimon' (δαίμων) to include the *manitu*, *nyarong*, and similar spirit helpers, and 'daimonism' as the name of the cult.

Theriomorphic Ancestor Worship.

Dr. Frazer calls attention[3] to a publication by Dr. G. McCall Theal[4] in which he describes the tribal veneration for certain animals, *siboko*. The Bantu believed that the spirits of the dead visited their friends and descendents in the form of animals. Each tribe regarded some particular animal as the one selected by the ghost of its kindred, and therefore looked upon it as sacred. Dr. Frazer says: 'Thus the totemism of the Bantu tribes of South Africa resolves itself into a particular species of the worship of the dead: the totem animals are revered as incarnations of the souls of dead ancestors. This entirely agrees with the general theory of totemism suggested by the late S. G. A. Wilken, and recently advocated by Professor E. B. Tylor.'[5] But is this totemism? The *siboko* are the residences of the ancestral spirits of the tribe, not of a clan; there is no mention of *siboko* exogamy. Is this anything more than theriomorphic ancestor worship? There can, however, be little doubt that true totemism did occur, and probably universally so, among the Bantu people; but some of the tribes appear to be in a transitional state, and others have doubtless passed beyond typical totemism. The decay of the Bantu totemism in South Africa appears to have been mainly due to a patriarchal organisation combined with a pastoral life.[6]

In describing Dr. Wilken's theory that the doctrine of the transmigration of souls affords the link which connects totemism with ancestor worship, Professor Tylor concludes as follows: 'By thus finding in the world-wide doctrine of soul-transference an actual cause producing the two collateral lines of man and beast which constitute the necessary framework of totemism, we seem to reach at least something analogous to its real cause.' I have already expressed my belief that the animal cults of the Malay Archipelago, so far as they are known at present, cannot be logically described as totemism, and the majority of the peoples of this area have so long passed out of savagery that we are hardly likely to find here an unequivocal clue to the actual origin of totemism.

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[1] *Journ. Anthrop. Inst.*, xxxi. 1901, p. 210.

[2] *Proc. Amer. Assoc. Adv. Sci.*, Section Anthropology, Detroit Meeting, 1897, pp. 325 ff.

[3] *Man*, 1901, No. 3.

[4] *Records of South-eastern Africa*, vii. 1901.

[5] *Journ. Anthrop. Inst.*, xxviii. p. 146.

[6] E. Durkheim, *L'Année Sociologique*, v. 1902, p. 330; *cf.* also F. B. Jevons, *Introduction to the History of Religion*, 1902, pp. 155, 158.

The reverence paid to particular animals or plants by certain groups of people in Fiji may, as Mr. Lorimer Fison says,[1] 'look like reminiscences' of totemism, but he has 'no direct evidence.' It surely belongs to the same category as the Samoan custom of which Dr. George Brown writes:[2] 'In Samoa every principal family had some animal which they did not eat, and I have always regarded this as meaning, not that they thought the animal divine, or an object of worship, but that it was the "shrine" in which their ancestral god had dwelt, or which was associated with some fact in their past history which had led them to adopt it as their totem.' An opinion which Professor Tylor has independently expressed,[3] but he naturally dissents from the incarnate god being termed a 'totem.'

I agree with Dr. Codrington[4] in doubting whether the evidence warrants a belief in totemism as an existing institution in the Southern Solomon Islands. I suspect that totemism has been destroyed over a considerable portion of Melanesia by the growth of secret societies as well as by theriomorphic ancestor worship. Herr R. Parkinson,[5] however, proves true totemism in the Northern Solomon Islands as the Rev. B. Danks had previously done[6] for New Britain, Duke of York Island, and New Ireland.

The more one looks into the evidence the more difficult is it to find cases of typical totemism; almost everywhere considerable modification has taken place, often so much so that the communities cannot logically be called totemistic. The magical increase of the totem by the clansmen does not appear to be common, but that may be due to its having been overlooked; on the other hand, magic may be performed against the totems to prevent them from injuring the crops, as in the case of the 'Reptile people' of the Omaha.[7]

Animal Brethren.

Throughout South-eastern Australia and probably elsewhere in that continent there is a peculiar association of a species of animal, usually a bird, with each sex. To take two examples given by Mr. A. W. Howitt,[8] 'the bird totems of the Kurnai are the Emu, Wren, and the Superb Warbler, which are respectively the "man's brother" and "woman's sister." . . . When we turn to the Kulin we find both the Kurnai totems in just the same position. In addition there are also a second male and female totem, namely, the Bat and the small Night-Jar.' Mr. Howitt is careful to point out, 'They are not true totems in the sense that these represent subdivisions of the primary classes; yet they are true totems in so far that they are regarded as being the "brothers" and "sisters" of the human beings who bear their names.' Mr. A. L. P. Cameron[9] also states that these are 'something different from ordinary totems.' Later Mr. Howitt[10] says: 'Among the Wotjobaluk tribe which have a true totemic system these were real totems although of a peculiar kind. They were called *yaur*, or "flesh," or *ngirabŭl*, or *mir*, just as were the totems proper. The only difference was that the Bat was the brother of all the men, while any one totem was the brother only of the men who bore it as their totem. . . . It is evident that the institution of the "man's brother" and the "woman's sister" as totems is very widespread throughout Australia. I have traced it over an extent of about a thousand miles and in tribes having marked differences in language and in social organisation. It seems to be very persistent and enduring, for it remained among the Kurnai in full force after the ordinary social organisation in class divisions and totems had become extinct.' Mr. Howitt speaks of these as 'abnormal totems,' and Dr. Frazer[1] calls them 'sex totems.' As it appears most desirable to distinguish between this cult, which is confined to Australia, and true totemism I propose, in default of a distinctive native term, to call these reverenced animals 'animal brethren.' Although the natives do not appear to distinguish nominally between these animal brethren and ordinary totems, it does not follow they are to be considered as the same. I am calling attention to an analogous confusion of terms in the totemism of Torres Straits.

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[1] *Ann. Rep. Brit. New Guinea*, 1897–98, p. 136.

[2] *Ibid.*, p. 137.

[3] *Journ. Anthrop. Inst.*, xxviii. p. 142.

[4] *The Melanesians*, 1891, p. 32.

[5] *Abh. Ber. k. Zool. Anth. Eth. Mus. Dresden*, vii. 1899, Nr. 6.

[6] *Journ. Anthrop. Inst.*, xviii. 1889, p. 281.

[7] J. O. Dorsey, *Ann. Rep. Bureau Ethnol.*, 1881–82 (1884), p. 248.

[8] *Journ. Anthrop. Inst.*, xv. 1886, p. 416.

[9] *Ibid.*, xiv. 1885, p. 350.

[10] *Ibid.*, xviii. 1888, pp. 57, 59.

I must now pass on to a further consideration of true totemism as understood by Tylor, Frazer, Lang, Hartland, Jevons, Durkheim, and others, as it is impossible within the limits of an Address to give an account of all the varieties of pseudo-totemism.

A Suggestion concerning the Origin of Totemism.

I take this opportunity to hazard a suggestion for a possible origin of one aspect of totemism. Primitive human groups, judging from analogy, could never have been large, and the individuals comprising each group must have been closely related. In favourable areas each group would have a tendency to occupy a restricted range owing to the disagreeable results which arose from encroaching on the territory over which another group wandered. Thus it would inevitably come about that a certain animal or plant, or group of animals or plants, would be more abundant in the territory of one group than in that of another. To take a clear example, the shore-folk and the river-folk would live mainly on different food from each other and both would have other specialities than fell to the lot of the jungle-folk. The groups that lived on the seashore would doubtless have some natural vegetable products to supplement their animal diet, but the supply would probably be limited alike in quantity and variety. Even they would scarcely have unlimited range of a shore line, and there would be one group of shore-folk that had a speciality in crabs, another would have shell-beds, while a third would own sandy shores which were frequented by turtle. A similar natural grouping would occur among the jungle-folk: sago flourishes in swampy land, certain animals frequent grassy plains, others inhabit the dense scrub, bamboos grow in one locality, various kinds of fruit trees thrive best in different soils; the coastal plains, the foot hills, the mountains, each has its characteristic flora and fauna. There is thus no difficulty in accounting for numerous small human groups each of which would be largely dependent upon a distinctive food supply the superfluity of which could be bartered[2] for the superfluities of other groups. These specialities were not confined to food alone; for example, the shore-folk would exchange the shells they collected for the feathers obtained from the jungle-folk.

It may be objected that in the great prairies and steppes of America, Eurasia, and Australia the natural products are very uniform; but these areas are not thickly populated, and in most cases they probably were only inhabited when the pressure of population in the localities with more varied features forced migration into the open. Certainly these were never the primitive homes of man.

In a recent paper read before the Folklore Society, Mr. Andrew Lang put forward the hypothesis that while each primitive human group called itself 'the men' they named the surrounding groups from the names of animals or plants, and hence arose totemism. The idea that there was an intimate connection between the group and the object from which they were nicknamed would soon be developed, and myths of origin would spring up to account for the name. Mr. Lang's theory, still unpublished, regards totem names as given from without for a variety of reasons, amongst which, I understand, he includes my own suggestion.

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[1] *Totemism*, p. 51; *The Golden Bough*, iii. p. 416.

[2] It may be objected that the idea of barter is by no means primitive; but as I believe that sociability was a fundamental characteristic of primitive man I can see no reason why it should not have occurred quite early in a rudimentary sort of way.

His conjecture is based on the similar names, or sobriquets, of villages in the folklore, or *blason populaire*, of France and England, which, again, is almost identical with the extant names of Red Indian totem kindred now counting descent in the male line. Similar phenomena occur in Melanesia with female kin. Mr. Lang is rather indifferent to the causes of the name-giving so long as the name-giving comes from without and applies to groups, not to individuals.

To return to my suggestion. Among the shore-folk the group that lived mainly on crabs and occasionally traded in crabs might well be spoken of as 'the crab-men' by all the groups with whom they came in direct or indirect contact. The same would hold good for the group that dealt in clams or in turtle, and reciprocally there might be sago-men, bamboo-men, and so forth. It is obvious that men who persistently collected or hunted a particular group of animals would understand the habits of those animals better than other people, and a personal regard for these animals would naturally arise. Thus from the very beginning there would be a distinct relationship between a group of individuals and a group of animals or plants, a relationship that primitively was based, not on even the most elementary of psychic concepts, but on the most deeply seated and urgent of human claims, hunger.

There is scarcely any need to point out that the association of human groups with fearsome animals would arise by analogy very early. Hence tiger-man and crocodile-man would restrain the ravages of those beasts (Dr. Frazer[1] describes this as the negative or remedial side of totemic magic); but I take it this was not as primitive as the nutritive alliances. The relation between groups of men and the elements has a purely economic basis; for example, rain is rarely required for itself, but as a means for the increase of vegetable food; similarly the fisherman wants a wind to enable him to get to and from his fishing grounds.

The next phase is reached when man arrived at elementary metaphysical conceptions and endeavoured by sympathetic or symbolic magic to increase his food supply. Naturally the food or product that each group would endeavour to multiply would be the speciality or specialities of that group, and for this practice we now have demonstrative evidence. Though this may be an early phase of totemism I do not consider it the earliest: it can scarcely be the origin of totemism, but it doubtless helped to establish and organise the system.

The essential difference between the view advocated by Dr. Frazer,[2] and that here suggested is, that according to him totemism 'is primarily an organised and co-operative system of magic designed to secure for the members of the community, on the one hand, a plentiful supply of all the commodities of which they stand in need, and, on the other hand, immunity from all the perils and dangers to which man is exposed in his struggle with nature. Each totem group, on this theory, was charged with the superintendence and control of some department of nature from which it took its name, and with which it sought, as far as possible, to identify itself.' Whereas I suggest that the association between a group of men and a species of animals or plants was the natural result of local causes, and that departments of nature were not 'assigned to a particular group' of men. I think it is scarcely probable 'that in very ancient times communities of men should have organised themselves more or less deliberately for the purpose of attaining objects so natural by means that seemed to them so simple and easy.' I suspect that if there was any deliberate organisation it was in order to regulate already existing practices.

To us it might appear that these magical practices could be undertaken by anyone, but this does not seem to have been an early conception. As far as we can penetrate the mind of existing backward man there is a definite acknowledgment of the limit of his own powers. The members of one group can perform a certain number of actions; there are others that they cannot undertake. One group of men, for example, may ensure the abundance of a certain kind of animal, but another will have power over the rain. An interesting example of this limitation is afforded at Port Moresby, in British New Guinea, where the

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[1] *Fortnightly Review*, 1899, p. 835.

[2] *Loc. cit.*, 1899, p. 835.

Motu immigrants have to buy fine weather for their trading voyages from the sorcerers of the indigenous agricultural Koitapu.[1]

The remarkable researches of Messrs. Spencer and Gillen in Central Australia prove that it is the function of the kinsmen of a particular totem to perform what are known as *intichiuma* ceremonies, the object of which is to cause the abundance of the species of animal or plant which is the totem of that kin. The descriptions of these ceremonies are well known to students.[2] I have adduced further evidence of a like nature,[3] and from what Mr. Roscoe has found in Uganda we may expect other examples from Africa.

It may be that in some, possibly in all, of the instances of sympathetic and symbolic magic there is a belief that wind or sun, animal or plant, or whatever the objects may be, are animated by spirits akin to those of humankind; but even so, as Dr. Frazer[4] points out, the action of the magician is a direct one: it does not imply the assistance of other powers who can control the body or spirit of those objects. The data from Australia and Torres Straits point to the conclusion that there is a magical aspect of totemism, which is of great economic importance, and there is no evidence that the officiators at these ceremonies acknowledge the assistance of spiritual powers resident either within the objects themselves or in the form of independent, more or less supreme beings. The existing data do not deny their existence, they simply ignore them in the ceremonies, and so far they are practically non-existent.

According to the suggestion I have ventured to make, the primitive totemic groups ate their associated animals or plants; indeed these were their chief articles of diet. Messrs. Spencer and Gillen point out[5] that while amongst most Australian tribes a man may not eat his totem, amongst the Arunta and other tribes in the centre of the continent there is no restriction according to which a man is altogether forbidden to eat his totem. On the other hand, though he may, only under ordinary circumstances, eat very sparingly of it, there are certain special occasions on which he is obliged by custom to eat a small portion of it, or otherwise the supply would fail. The Arunta are a peculiar people, while they may be primitive in some respects; in others they are not so, as also has been pointed out by Durkheim.[6] According to the strict definition of the term, they are not even a totemic people. Judging from the evidence of the legends of the Alcheringa time and the traces of group marriage and mother right, Mr. Hartland[7] is of opinion that the present disregard by the Arunta of the totem in marriage is a stage in the sloughing of totemism altogether, whereas the *engwura*, or final initiation ceremonies, indicate that 'the organisation is undergoing a slow transformation into something more like the so-called secret societies of the British Columbian tribes.'

The eating of what are evidently the totem animals by the Arunta may possibly be a persistence from an earlier phase, but, without doubt, the totem taboo is characteristic of totemism in full sway.[8] We have evidence to show that under certain conditions the totem taboo may break down, but this is a later transformation, and indicates a breaking up of the rigid observance of totemism.

Mr. Lang[9] has made a simple suggestion to account for the origin of the totem taboo. He says: 'These men therefore would work the magic for propagating their kindred in the animal and vegetable world. But the existence of this connection would also suggest that, in common propriety, a man should not kill and eat his animal or vegetable relations. In most parts of the world he abstains from this uncousinly behaviour; among the Arunta he may eat sparingly of his totem, and must do so at the end of the close-time or beginning of the season. He thus, as a near relation of the actual kangaroo or grubs, declares the season is open, now his neighbours may begin to eat grubs or kangaroos; the taboo is off.' Dr. Frazer puts forth two suggestions:[1] the one is that as animals do not eat their own kind, so man thought it inconsistent to eat his totem kin; the other is a hypothetical idea of conciliation.

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[1] J. Chalmers, *Pioneering in New Guinea*, 1887, p. 14.

[2] Baldwin Spencer and F. J. Gillen, *The Native Tribes of Central Australia*, 1899; *cf.* also J. G. Frazer, *Fortnightly Review*, 1899, pp. 648, 835.

[3] *Folk-lore*, xii. 1901, p. 230, and *Report Camb. Anthrop. Expedition to Torres Straits*, vol. v. (in the press).

[4] *Loc. cit.*, 1899, p. 657.

[5] *Loc. cit.*, pp. 73, 167.

[6] *L'Année Sociologique*, v. 1902.

[7] *Folk-lore*, xi. 1900, pp. 73–75.

[8] I am fully aware that this appears to cut the ground from under my suggestion; but the latter deals with incipient totemism, and I do not see why the totem taboo should not have arisen from several causes.

[9] *Magic and Religion*, 1901, pp. 264, 265.

I have barely touched upon the relation of social organisation, with its marriage taboo, to totemism. It is by no means certain that the social regulations and customs, which are so much in evidence in a fully developed totemic society, were primitively connected with totemism. So far as the Arunta are concerned, Messrs. Spencer and Gillen believe[2] the 'totemism appears to be a primary, and exogamy a secondary, feature . . . and that exogamic groups were deliberately introduced so as to regulate marital relations.' But is this primitive?

If one admits that mankind was originally distributed in small groups, which must have consisted of near kin, it does not seem difficult to imagine that marriage would more likely take place between members of contiguous groups rather than within the groups themselves. The attraction for novelty must always have operated, and in the struggle for existence there was always one advantage to be gained by alliances between neighbouring groups, not only from a commissariat point of view, but for offensive and defensive purposes. There is, of course, the converse of this, as wife-stealing would lead to feuds; perhaps daughter-abduction was more frequent, and this probably was not regarded as an offence so serious that a mild scrimmage would not set matters right. It would not take long for wont to crystallise into rigid custom, and custom is always supported by public opinion.

Social regulations must be later than social conditions, and I suspect that the privileges and taboos which run through the social aspect of totemism first arose when totemic groups were in process of aggregation into more complex communities, and afterwards gradually became fixed into a system.

Hero-cults.

The facts to which I have hitherto directed your attention fall well within the sphere of totemism, but I wish now to indicate two interesting departures from typical totemism, both of which occur among the Western tribe of Torres Straits.

I have alluded to the dual grouping of the totem kins at Mabuiag, and an analogous arrangement occurred in the other islands; I propose to speak of each group of kins as a phratry. Strictly speaking, a phratry is a group of exogamous kins within a community; that is, no member of a group of kins (or phratry) could marry another person belonging to the same phratry. The evidence that this is or was the case in the Western tribe of Torres Straits is strong, but it is not absolutely proven.

In Yam, as in the other islands, there is at least one *kwod*, or taboo ground, where sacred ceremonies were held. In the principal *kwod* in Yam there was formerly a low fence surrounding a space about thirty-five feet square in which were the shrines of the two great totems of the island. All that now remains is several heaps of great Fusus shells.

Two of the heaps are about twenty-five feet in length. Formerly at the southerly end of each long row of shells was a large turtle-shell (tortoise-shell) mask representing respectively a crocodile and a hammer-headed shark. These were decorated in various ways, and under each was a stone in which the life of the totem resided; stretching from the front end of each mask was a cord to which numerous human lower jaw-bones were fastened, and its other end was attached to a human skull, which rested on a stone. Beside the shrine of the hammer-headed shark was a small heap of shells which was the shrine of a sea-snake, which was supposed to have originated from the shark. These shrines were formerly covered over by long low huts, which like the fence were decorated with large Fusus shells.

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[1] *Fortnightly Review*, 1899, pp. 838–40.

[2] *Journ. Anthrop. Inst.*, xxviii. 1899, pp. 277, 278.

Outside the fence were two heaps of shells which had a mystical connection with the shrine: they were called the 'navels of the totems.'

I have referred to the *intichiuma* ceremonies of the Arunta tribe of Central Australia as being magical rites undertaken by certain kinsmen for the multiplication of the totems. In some cases, apparently, the ceremonies may take place wherever the men happen to be camping; in other cases there are definite localities where they must be performed, as there are in these places certain stones, rocks, or trees which are intimately connected with the magical rites. These spots may be spoken of as shrines. In the island of Mabuiag the magical ceremony for the alluring of the dugong was performed by the men of that kin in their own *kwod*, which was a fixed spot; and doubtless this was the case in the other islands of Torres Straits, for even in the small islands there was a tendency to a territorial grouping of the kins. This localisation of a totem cult has proceeded one step further in Yam Island. Here we have a dual synthesis. The chief totem of each group of kins is practically alone recognised; in other words, the various lesser totems are being absorbed by two more important totems. Each totem has a distinct shrine, and the totem itself, instead of being a whole species, is visualised in the form of a representation of an individual animal, and this image was spoken of as the totem (*augud*). Indeed, the tendency to concretism had gone so far that the life of the *augud* was supposed to reside in the stone that lay beneath the image,[1] and certain heaps of shells were the navels of the totems, a further linkage of the totem to that spot of ground.

A suggestion as to the significance of this transformation is not lacking. There are various folk-tales concerning a family of brothers who wandered from west to east across Torres Straits. Some of them were, in a mysterious way, sharks as well as men. The two brothers who went to Yam were called Sigai and Maiau, and each became associated, in his animal form, with one of the two phratries. The shrines in the *kwod* were so sacred that no women might visit them, nor did the women know what the totems were like. They were aware of Sigai and Maiau, but they did not know that the former was the hammer-headed shark and the latter was the crocodile; this mystery was too sacred to be imparted to the uninitiated. When the totems were addressed it was always by their hero names, and not by their animal or totem names.

Malu, another of these brothers, introduced the cult that bears his name to the Murray Islanders, who form part of the Eastern tribe. He also was identified with a hammer-headed shark. Totemism, as such, had practically disappeared from Murray Island before the advent of the white man, and the great ceremonies at the initiation of the lads into the Malu fraternity were a main feature of the religion of these people.

In Yam totemism was merging into a hero cult; in Murray Island the transformation was accomplished; the one had replaced the other.

In Mabuiag, one of the Western Islands, there was a local hero named Kwoiam whose deeds are narrated in a prose epic. Kwoiam made two crescentic ornaments of turtle-shell, which blazed with light when he wore them at nighttime, and which he nourished with the savour of cooked fish. These ornaments were called totems (*augud*)—presumably because the natives did not know by what other sacred name to call them—and they became the insignia of the two groups of kins of Mabuiag. The crescent which was worn above Kwoiam's mouth was regarded as the more important, and those kins which had land animals for their totems were called from it 'the children of the great totem,' but the water group were called 'the children of the little totem.' There is reason to believe that the dual grouping of the kins is ancient. The erecting Kwoiam's emblems as the head totems of the two groups of kins must be comparatively recent. Here again the primitive association of a group of men with a group of natural objects obtains in the small groups or totem-kins, but in the larger synthesis a manufactured object replaces a group of animals, and this object possesses definite magical powers. There were two navel-shrines connected with the cult of Kwoiam, which were constructed to show that the two *augud* were born there. When it was deemed necessary to fortify the *augud*—that is, the emblems—they were placed on their respective navel-shrines. Further, in Muralug and the adjacent islands Kwoiam himself was a totem (*augud*). Thus in the westernmost islands of the Western tribe the transition from totemism to hero-worship was in process of evolution till it was arrested by the coming of the white man.

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[1] For the keeping of a soul in an external receptacle, and for Dr. Frazer's views on its bearing on totemism, cf. *Fortnightly Review*, May 1899, p. 844; *The Golden Bough*, iii. 1900, pp. 418–422; and S. A. Cook, *Jewish Quart. Review*, 1902, p. 34 of reprint.

To what was this transformation due? It is not very easy to answer this question. We have evidence that in comparatively recent times a change took place in the social organisation of the people, and that the former matriarchal conditions had been replaced by patriarchal. Although superficially the marriage system of the Western tribe appears to be regulated by totemism, Dr. Rivers has found[1] that it is really a relationship system, and that descent, rather than totemism, is the regulating factor. The Eastern tribe, as represented by the Murray Islanders, had progressed further along this road than had the Western tribe. Such a change as this could not fail to have a disturbing effect upon other old customs.

The folk-tales that I collected clearly indicate a migration of culture from New Guinea to the Western tribe, and from the Western tribe to the Eastern tribe. I believe I can demonstrate the migration from New Guinea of a somewhat broad-headed people that spread over the Western Islands but barely reached Murray Island. It is conceivable that the culture myths have reference to this migration, and that the gradual substitution of a hero cult for totemism may be part of the same movement; but, on the other hand, this social and religious change is most thorough in Murray Island, where, I imagine, the racial movement has been least felt. The isolation of Murray Island from outside disturbing factors is very complete, and, as it is but a small island, a change once started might take place both rapidly and effectively.

It is interesting to note that the totem heroes of the Western tribe were invoked when their votaries were preparing to go to war. I obtained the following prayer in Yam Island:—'O *Augud* Sigai and O *Augud* Maiau, both of you close the eyes of those men so that they cannot see us,' which had for its intent the slaughtering of the enemy without their being able to make a defence. I was informed that when the Yam warriors were fighting they would also call on the name of Kwoiam, who belonged to another group of islands, and on Yadzebub, a local warrior. Yadzebub was always described as 'a man,' whereas Kwoiam and Sigai were relegated to a 'long time' back. From the folk-tales it is evident that Sigai and Maiau are more mythical or mysterious than Kwoiam. We thus have an instructive series: Yadzebub, the local famous man; Kwoiam, the hero, who was also a totem to other people; and Sigai and Maiau, the local totem heroes whose cult was visualised in turtle-shell images, and the life of each of whom resided in a particular stone. Perhaps it would be more correct to speak of this as the grafting of a new cult on totemism rather than to describe it as an evolution of totemism. A transformation has certainly occurred, but it does not appear to me to be a gradual growth—a metamorphosis in the natural history sense of the term—so much as the pouring of new wine into old bottles.

I hope on another occasion to deal with the question of religious and secret societies, as the growth of these has invariably disintegrated whatever antecedent totemism there may have been.

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[1] *Reports Camb. Anthrop. Expedition to Torres Straits*, v. 'Kinship' (in the press).

It is highly probable that something like what was taking place in Torres Straits has occurred elsewhere, but I cannot now enter into a comparative study of the rise of hero cults.

Local or Village Exogamy.

I have more than once[1] called attention to the fact that among some Papuans marriage restrictions are territorial and not totemic. Dr. Rivers[2] has shown that in Murray Island, Eastern tribe of Torres Straits, marriages are regulated by the places to which natives belong. A man cannot marry a woman of his own village or of certain other villages. The totemic system which probably at one time existed in this island appears to have been replaced by what may be called a territorial system. A similar custom occurs in the Mekeo district of British New Guinea, and it is probably still more widely distributed.

I was informed by a member of the Yaraikanna tribe of Cape York, North Queensland, that children must take the 'land' or 'country' of their mother; all who belong to the same place are brothers and sisters, a wife must be taken from another 'country';[3] thus it appears their marriage restrictions are territorial and not totemic. The same is found amongst the Kurnai and the Coast Murring tribe in New South Wales.[4]

At Kiwai, in the delta of the Fly River, B.N.G., all the members of a totemic group live together in a long house which is confined to that group. I have also collected evidence which proves there was a territorial grouping of totemic clans among the Western tribe of Torres Straits.[5]

Within a comparatively small area we have the following conditions:—

(1) A typical totemic community with totem-kin houses (Kiwai).

(2) A typical totemic community with territorial grouping of the kins. Although there is totem exogamy, the marriage restrictions are regulated by relationship. The former mother-right has comparatively recently been replaced by father-right, but there are many survivals from matriarchy (Western tribe, Torres Straits).

(3) A community in which totemism has practically lapsed, with village exogamy and marriage restrictions regulated by relationship, patriarchy with survivals from matriarchy (Eastern tribe, Torres Straits).

(4) Total absence of totemism (?), village exogamy (Mekeo).

I do not assert this is a natural sequence, but it looks like one, and it appears to indicate another of the ways out of totemism. It is suggestive that this order also indicates the application of the several peoples to agriculture: the people of Kiwai are semi-nomadic, those of the Mekeo district are firmly attached to the land. This constraint of the soil must have operated in a similar manner elsewhere.[6] The territorial exogamy occasionally found in Australia cannot be explained as being due to agriculture; a rigid limitation of hunting grounds may here have had a similar effect.

In offering these remarks to-day I desire, above all, to impress on you the need there is for more work in the field. When one surveys the fairly extensive literature of totemism one is struck with the very general insufficiency of the evidence; as a matter of fact, full and precise information is lamentably lacking. The foundations upon which students at home have to build their superstructures of generalisation and theory are usually of too slight a character to support these erections with much chance of their permanence. There is only one remedy for this, and that is more extensive and more thorough field work. The problems connected with totemism bear upon many of the most important phases in the social and religious evolution of man, the solution of which can only be obtained within the space of a few years. The delay of each year in the investigation of primitive peoples means that so much less information is possible to be obtained. There is no exaggeration in this. Those who have a practical experience of backward man and who have travelled in out-of-the-way places can testify as to the surprising rapidity with which the old order changeth. In sober earnestness I appeal to all those who are interested in the history and character of man, whether they be theologians, historians, sociologists, psychologists, or anthropologists, to face the plain fact that the only available data for the solution of many problems of the highest interest are daily slipping away beyond recovery.

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[1] *Folk-lore*, xii. 1901, p. 233; *Head-hunters, Black, White, and Brown*, 1901, p. 258.

[2] *Journ. Anthrop. Inst.*, xxx. 1900, p. 78.

[3] *Brit. Assoc. Report*, Dover, 1899, p. 585.

[4] Frazer, *Totemism*, p. 90.

[5] *Reports Camb. Anthrop. Expedition to Torres Straits*, v. (in the press).

[6] Cf. *L'Année Sociologique*, v. 1902, pp. 330, 333.

The following Papers were read:—

1. *The Initiation Ceremonies of the Natives of the Papuan Gulf.*

By Rev. J. H. Holmes.

If his friends can afford it, a boy is isolated in the *eravo* at the commencement of puberty, and he is not released until his hair has grown to its full length. An old man looks after the boys and instructs them. There are several taboos: seeing or speaking to women; certain food; utensils. The boy is taught to be brave, and all social customs attending birth, courtship, marriage, and death, as well as religious duties. During the seclusion the boy's body must not be exposed to the sun, so that they may have strong bodies and grow into big men. The bull-roarer, *tiparu*, is shown and explained. Masks play a great part in the more important ceremonies.

2. *The Religious Ideas, Totems, Spirits, and Gods of Elema.*

By Rev. J. H. Holmes.

From certain customs and taboos it is evident the natives of the Papuan Gulf were totemic peoples, but they appear to have partially passed beyond this phase.

There are four classes of spirits: (1) Of those who have died a natural death; (2) of those who have died in a fight; (3) of those who have been murdered; (3) of those killed by crocodiles.

Several tribes of the Papuan Gulf believe in gods. For example, Kivavea is the deified ancestor of the Vailala tribe; this is the Kivovia of the Toaripi, who made sago, betel-nuts, &c. Other gods of the Toaripi are Harisu, the chief god, who presides over hosts of deities; occasionally a man is recognised as his messenger (*Harohoha*) to men. Karisu is the evil god, who presides over the host of the sub-deities of evil. Ualare is the god who made the sun, moon, and stars, the sea and all that is therein, and the land and what lives on the land, with the exception of certain kinds of food. Ivaove Maialaove is the god of death. Saukroo is a tree-god who kills men. Hiovaki is the god of war who terrifies the enemy, and only those who fall in battle go to him. The banana has two gods, the sweet potato has one: the taro has another. Every family of living things, from man downwards, has its special god or guardian angel, for whom there is a feeling of respect.

3. *Human Souls and Ghosts among the Malays of Patani.*

By Nelson Annandale.

After summarising the sources of information the paper describes the Malay beliefs as to the various non-material elements and their functions in man, the ghosts of murdered men, and the other ghosts that arise from men in an ill-defined manner. It discusses the question of *kramat* and inspired magicians; the ghosts of such inspired magicians; the giving in marriage of the son of such a ghost and the marriage procession—a cyclone; the evolution of a local god from such a ghost; and concludes with an account of the cult of 'Toh Ni.

4. *Cornelius Magrath, the Irish Giant.*
By Professor D. J. CUNNINGHAM, *M.D., F.R.S.*

5. *On a Skull modified by Acromegaly.* *By* Professor A. F. DIXON, *M.B.*

6. *Exhibition of Specimens illustrating Physical Anthropology.*
By Professor J. SYMINGTON, *M.D., F.R.S.E.*

7. *On some Ulster Souterrains.* *By* WILLIAM J. FENNELL.

The north-east corner of Ireland is peculiarly rich in evidences of prehistoric man. Though no houses of any kind are known to exist which are attributable to the Stone Age, there is another class of built structure—the *souterrain*—which may be claimed as the primæval architecture of the country, for these *souterrains* exist in great numbers, and fresh ones are constantly coming to light.

A *souterrain* may be defined as a subterranean place of refuge—and in that sense only, a dwelling. The entrance to *souterrains* is either naturally difficult of approach or cunningly hid, and its interior is generally long, low, narrow, and winding, and beset with frequent barriers, locally known as 'difficulties,' through which only one person could pass at a time, and then only by creeping. If these were the abodes of peace this succession of barriers would have no meaning, although one at the entrance might be useful.

That they were not burial-places is evident, as no relics of early cremation or remains of human bones, or, in fact, of any kind, have been found in them. One recently discovered at Stranocum, near Ballymoney, contained only a small fragment of a cow bone. This latter *souterrain* is constructed inside a *rath*, and has a communication running under the ramparts to the outer escarpment—either as an exit or as a vent. The built burying-places or sepulchral-chambers for cremated remains, such as those at Douth and New Grange, are far in advance of the *souterrain* from a building point of view, and also bear indications of a love of decoration on strong, if undecided lines, which point to a more recent and advancing people.

The *souterrains* are not burrows, but vaulted chambers connected by passages, well defended, and built of dry masonry walls and roofs, and afterwards covered up by earth and eventually hidden by vegetation. The exterior covering is always very thin, so that in many cases they are close to the surface. The construction is invariably of rough unhewn stones from the neighbourhood—chiefly of smooth ice-worn boulders, which are found in such profusion in these districts; but in some cases the stones are large and placed in upright positions, and the roof is invariably formed by the overlapping of one stone on another, a system followed into much more recent times.

The barriers are formed of walls rising from the floor almost to the roof, then a space of 12 or more inches to the next wall, which descends from the ceiling to within 15 inches of the floor, and leads in some cases to a long low tunnel 16 or 18 inches high, with a similar barrier at the other end.

No two *souterrains* are alike in plan; some are straight, or almost so, with chambers branching off; some like the letter F or W, and some slightly circular—like that of Artole near Ardglass. Some are extremely short, while others are considerably over 100 feet long.

The *souterrain* at Muckamore is a solitary example of a two-storey building entered from the field-level to the upper floor and from that to the lower one.

It is impossible to assign a date to these rough rude structures, but the diminutive one at Connor, County Antrim, has two Ogham stones inserted, so that at least some of them must have been erected much later by a race who used an alphabet. It shows a distinct advance in building construction in the use of a series of lintel stones—including the Ogham ones—to support the roof, but even in this case it seems to have been simply a place of refuge.

8. *On some Ancient Subterranean Chambers recently discovered at Waddon, near Croydon. By* George Clinch, *F.G.S.*

Excavations for a sewer at Waddon House, near Croydon, in June 1902, revealed three subterranean chambers cut in a bed of Thanet sand, and partly occupied by sand which had fallen or been washed into them. In each chamber, however, a compact floor was found at about 15 feet below ground. The chambers were of beehive shape, about 7 feet high and 12 feet or less in diameter. Each had its independent entrance opening on the south-south-east side, but no other means of access till the domed roofs were cut open by the sewer trench.

Below the sand which covered the floors of the chambers several cores and chips of green-coated flints were found, with small fragments of imperfectly baked pottery, and larger fragments of Romano-British pottery. These green-coated flints occur at the base of the Thanet beds, whereas the chambers were excavated 10 to 15 feet above the base; the flints must therefore have been procured lower down, near Waddon Station (where there is an outcrop of the bed in which they occur), and brought up the hill to the chambers. This could not have been done by rain wash or similar agencies.

The small dimensions and the form and plan of the Waddon chambers, the absence of a perpendicular shaft, and their occurrence in sand, differentiate them entirely from the so-called 'dene-holes'; nor have they any feature in common with the 'flint-mines' of Grime's Graves and Cissbury, nor with the beehive-shaped cavities found in the Isle of Purbeck in 1883.[1]

On the continent of Europe the most similar chambers are those at Palmella in Portugal, which M. Cartailhac ascribes to sepulchral purposes in the latter end of the Polished Stone Age.[2] In particular, the flat floors and hemispherical vault-like sides and roofs are common to both; and the thickening of the walls near the doorway—a provision, as M. Cartailhac notes at Palmella, against the special wear and rubbing to which these parts are subject—recurs in two at least of the Waddon chambers. Similar chambers have been noted in Brittany and elsewhere. The subterranean 'beehive tombs' at Mycenæ, also, are identical in plan, though different in dimensions and material.

Bones of *Bos taurus* (? *longifrons*), horse, dog, or wolf, &c., were found in the loose sand in the Waddon chambers, but no human bones; nevertheless, the evidence seems to show that the chambers were primarily sepulchral. Subsequent disturbance, however, is indicated by the later objects found in the loose sand, and by certain rude scratches—possibly mediæval—on the curved roof, variously interpreted by different observers as a bird, an animal, or a boat.

South-east and east of Waddon there are many hut circles which have been attributed to the Neolithic Age. They are circular in form, with marks of entrances on the east and south-east side, and exhibit general resemblance in dimensions and plan with the Waddon chambers. On the steep side of Croham Hurst (about three miles south-east of Waddon) traces of similar dwellings are recorded, and may very likely have influenced the design of the sepulchral chambers, as so often happens.

The Waddon discovery is therefore of some importance as evidence for the size, shape, plan, &c., of prehistoric dwellings; the vaulted roofs cut in hard sand reproducing, in general form, the interlaced boughs, benders, and wicker-work of the ordinary surface hut, and the lateral passage the doorway of the neolithic dwelling.

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[1] *Proc. Geol. Assoc.*, viii. 7 (July 1884) pp. 404–410.

[2] *Matériaux*, 3 Ser. II. (1885) pp. 1–18; reprinted in Cartailhac's *Les Ages pré-historiques de l'Espagne et du Portugal.*

The same idea of interment within a house survived during the Bronze Age; but when cremation came into vogue, a miniature copy of the Bronze Age house—the 'hut-urn'—was sufficient repository for the ashes.

The tradition of the circular neolithic hut was carried on in the Celtic beehive dwellings of Cornwall, Wales, Scotland, Ireland, and Gaul, and probably in the circular buildings of subsequent English architecture. The Bronze Age dwellings, on the other hand, which are reproduced in the 'hut-urns,' may be regarded as the prototypes of the square or angular forms of ecclesiastical and domestic architecture.

9. *Underground Dwellings in the British Isles.*
By DAVID MACRITCHIE, *F.S.A.Scot.*

The primitive underground habitations described in the paper are typical of a class of structure apparently existing at one time throughout the British Isles, though the greater part of the specimens now remaining are found in Ireland and Scotland. It is hardly possible to conceive of human dwellings more archaic in character, and yet some of them, if not all, belong to times that are quite historic. Two specimens, one at Crichton in Mid-Lothian, and the other at Newstead in Roxburghshire, must have been built after the arrival of the Romans in Britain—and probably a long time after that date—for the reason that a number of dressed stones with Roman ornamentation have been used in their construction, presumably taken from Roman ruins.

That these underground structures were used as places of human abode is obvious, because they contain domestic utensils, such as hand-mills and personal ornaments, as well as the broken bones of animals used by man as food. In a few instances they have a fireplace, but this is very exceptional. Like the similar dwellings of the Eskimos, these underground habitations are so well protected from the cold of even the keenest winter that a fire is not necessary, and oil lamps suffice for heating, lighting, and cooking. From their characteristics, therefore, these underground structures quite justify the name of 'earth-house,' which is given to them in the Norse sagas and also in living popular speech.

In appearance they vary considerably, but most of them have their roofs about a foot or two below the surface of the ground, entrance being obtained from above by one or more downward-slanting passages. They are built of rough, undressed, unmortared stones, the walls gradually converging until they meet in a 'Cyclopean' or 'false' arch, completed by large flagstones laid across. In some cases their very small dimensions support the traditional belief that they were built for a dwarfish race.

FRIDAY, SEPTEMBER 12.

The following Papers and Report were read:—

1. *The Oldest Bronze-age Ceramic Type in Britain: its Close Analogies on the Rhine; its Probable Origin in Central Europe.*[1] *By the* Hon. JOHN ABERCROMBY.

The oldest Bronze-age type of pottery in Britain is the 'drinking-cup,' for which it is proposed to substitute the shorter term 'beaker.' Thurman recognised three types, designated α, β, γ. Twenty examples of α, sixteen of β, and seventeen of γ, are illustrated. Type α seems to be the oldest and γ to be derived from it; β has a different secondary origin from α. Twenty-five interments are described in which the beaker was accompanied by ancient objects; three with large flint daggers, three with buttons with the V-shaped perforation below, and five with stone wrist-guards, all of which objects belong to the later neolithic period on the Continent. None of the objects found with the remaining fourteen interments are of later date than the thin, flat, broad knife-dagger. As no other ceramic type in Britain can show such a pedigree, it is clear that the beaker is the oldest, though before it died out several other types of fictilia came into use. The beakers found with food-vessels and burnt interments are shown by their form and ornament to belong to a rather late period. As ornamentation is a very important subject, fifty-nine examples taken from the three types are exhibited and contrasted. Some later developments are pointed out. The ornament, like the form, points to a different secondary origin for a and β.

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[1] Will be published *in extenso* in the *Journal of the Anthropological Institute.*

The localities where beakers have been found in Great Britain and Ireland are shown on a map. Though β is the least represented numerically, it has the widest diffusion. It extends from the coast of Sussex to Sutherland—perhaps to the Shetlands—and is the only type at present known in Ireland.

Ten photographic examples of type β from the Rhine, between Coblenz and Mainz, are compared with ten British. The ornament of the Rhenish examples is shown on a slide and compared. Some of the ornament on the Rhenish beakers is borrowed from a different type, known as the 'bell-shaped beaker.' This particular system of ornamentation is not found west of the Rhine Valley, south of the Danube, east of about the longitude of Vienna, or north of the latitude of Berlin.

The origin of type a can only be suggested, not demonstrated. Its form seems derived from the much earlier *Schnur-becher* and its later off-shoots, a few examples of which will be exhibited on a slide. But the practice of distributing the ornament in zones or bands is probably owing to the influence of the 'bell-beaker,' one example of which is shown. This is an extension of Dr. Götze's theory. Type β is derived from a type much more influenced by the 'bell-beaker,' though some examples of it are perhaps merely later modifications of the 'bell-beaker.' In type a the influence of the 'bell-beaker' is much less direct, so that, supposing both a and β are off-shoots of the 'cord-beaker,' they have different secondary origins, but go back to a common form at a point in time many centuries earlier. But the possibility is not excluded that the origin of β is to be referred entirely to the 'bell-beaker,' in which case a and β have an independent origin.

The areas in Central Europe where the 'cord-beaker' and its off-shoots, as well as the 'bell-beaker,' are found, are Northern Bohemia and the region of the Saale, a western tributary of the Elbe. As a fully developed type β occurs on the Rhine, both at the centre of its course and near its mouth. From the Rhine it passed over to Britain.

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2. *On Objects of the Plateau Kind from the Interglacial Gravels of Ireland.*

By W. J. KNOWLES.

A few years ago I obtained from Mr. Benjamin Harrison a selection of plateau implements from the South of England. I found that the forms and style of workmanship were not new to me, as I had met with somewhat similar objects in Ireland. These mostly belonged to the class which I had often described as the older series of Irish flint implements. The Irish objects, like the English plateau implements, showed in most cases a dark-brown patina and 'the fashion of chipping the flint perpendicularly through the thickness.' Lately I have obtained from gravels of interglacial age in Galgorm Parks, Co. Antrim, flints showing the same warm brown patina and the 'perpendicular chipping through the thickness.' Among the Irish specimens is one fairly large object, 5½ inches long, which is not unlike a palæolithic implement in outline, but the only dressing it shows is of the perpendicular kind round the sides. It fits the hand, and would be a useful implement for striking, if stunning, not cutting, were the object in view. It resembles some of the English plateau examples in shape, but is much larger. The Irish specimens are as yet few, as I do not know of anyone except myself who has collected them; but if attention were drawn to them I believe the number of them could be greatly increased. The definition given above is from a very instructive and temperate paper by Mr. R. D. Darbishire, F.S.A., to the Manchester Literary and Philosophical Society. He believes in the artificial character of the implements. There are two questions which it appears to me should be solved in regard to these implements: (1) What useful object could the perpendicular chipping serve to man? and (2) If not artificial, what force in Nature can dress so many objects alike with chipping that has all the appearance of being artificial in character?

3. *On Stone Axe Factories near Cushendall, Co. Antrim.*
By W. J. KNOWLES.

There are several centres where stone axes have been manufactured in the neighbourhood of Cushendall, but they are most numerous in Glen-Ballyemon. One well-marked site, in a field belonging to Mr. Richard McCurry in the townland of Tamnaharry or Tavnaghharry, was observed about three years ago on the natural pasture being broken up. Many axes in the rudely chipped state were found in it—some whole, others broken, probably in the course of manufacture. Mixed up with these were pick-like objects, scrapers, and numerous rounded balls (evidently hammer-stones) of the same kind of stone as that from which the axes were made; flakes, too, were in great abundance. Many of the flakes showed dressing or marks of use along the edges. The field containing these objects has an elevated position, and commands a fine view. There was probably an encampment at this place, though I could observe no signs of kitchen-middens or remains of food, such as split bones. On walking away from this centre flakes and other signs of manufacture grew less frequent, and eventually ceased.

Another site was found on the farm of Mr. James Quinn in Clougheen. The signs of industry appeared thickest around a damp spot (probably an ancient well) in a field near his house.[1]

Other sites are found on Mrs. Darragh's farm in Cloughs, near the top of the ridge separating Glenann from Ballyemon, in Muroo and Knockans. Other centres of manufacture are found around Tievebulliagh, a prominent peak 1,346 feet high; and several sites containing many objects of the kind enumerated, with large quantities of flakes, were found near the top of Tievebulliagh itself. These when discovered were in a perfectly undisturbed condition. Implements and flakes similar in kind to those described have been found in Glenariff, Glenann, and Glendun, indicating sites of manufacture.

The rock from which most of the axes are formed is not, I think, native to the district. It is of a close-grained, bluish kind, and appears to be metamorphic. It occurs in the valley in the form of boulders showing glacial striæ, and weighing from about two pounds up to several hundredweight. Many of the larger boulders, some of which are firmly embedded in boulder clay, have been hammered and flaked, in order no doubt to procure large flakes or spalls for axes. Over six hundred whole axes and about as many broken specimens have been obtained from the various sites. The flakes, which are all of the kind produced in the manufacture of implements, are in thousands. Sometimes at a short distance they appear like pieces of roofing slate that have been broken and scattered over the field.

While some of the axes are finely finished, others are very rude. All stages in the manufacture can be easily traced. We see the boulder with a few chips removed, also specimens showing more and more chipping, till we reach the completed axe. Some of the ruder kinds are crooked, unsymmetrical, and sometimes so blunt at the part intended for the cutting edge that one would be inclined to regard all these as failures; but, judging from some rude specimens that have been partly ground and polished, I have come to the conclusion that a piece of good rock was not rejected on account of its not working true. When a lump could not be removed by the hammer-stone, or a thick edge could not be made finer, it appears to me that the specimens showing such defects were not regarded as failures, but that all was set right by patient grinding.

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[1] There is a *bullaun* stone on the ditch opposite this place.

The axes are of various sizes. One fine specimen is 14¾ inches long and weighs 8¾ lb.; some weigh 5 lb., others 4 to 3 lb. The average specimen would weigh about 1 lb., and some small chisel-like objects only 1 oz. or 2 oz.

Looking over a collection of polished stone axes, I find various types, some of which might be considered of a newer pattern than others, either introduced or developed from an older type; but we find here most types among the rudely made specimens—edges showing various forms of curve, expanding edges, squared sides, swages, and even kitchen-midden types—all made in these forms at the first, and apparently contemporaneous.

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4. *The Manufacture of Arrow- and Spear-heads.* *By* W. J. KNOWLES.

The majority of Irish flint arrow- and spear-heads are made from flint flakes. Many specimens, even when highly finished, show traces of the bulb of percussion or of the ridge on the back of the flake. In some the plain undressed ridge of the flake still remains, the edges only being slightly dressed. There are examples showing a stem or barbs at the base with the natural point of the flake to act as the point of the arrow. Sometimes in such objects there is a slight trimming at the extreme point. We sometimes see specimens with barbs, but blunt and unfinished points. At same time we find nicely dressed points with undressed butts. There are arrow-heads well finished at both butt and point, but so crooked that one cannot see how they could be made serviceable. In many cases we can see that great efforts have been to neutralise by work the curve of the flake. In a large series where both good and poor specimens have been collected, the various stages of workmanship can be seen, from the first beginnings up to those very fine and perfectly chipped specimens which are so thin that they are almost transparent.

All collectors of flint implements must have specimens such as are mentioned above, and have no doubt observed the various stages in the process of manufacture of arrow- and spear-heads; but there is another kind of rude flint objects, of a leaf shape, found occasionally on manufacturing sites, which has not been observed, or at least noted, as far as I know, by collectors. These are ovate or oval objects, varying from 4 to 2 inches in length, the flaking on which, being coarse and irregular, must have been produced by blows from a hammer-stone. Some specimens have evidently been made from small boulders, some from half-boulders, and others from coarse flakes. They are so rude, some being without points, that they could not be used in their present condition as implements, but, I believe, were blocked-out spear- and arrow-heads, which were intended to be worked into useful implements by means of a flaking tool. No hoard of such objects, so far as I know, has been found in Ireland; but, having long put articles having similar peculiarities together, I find, on counting up after thirty years, that I have accumulated over 200 specimens of these rude objects. They come from various well-known sites—Whitepark Bay, Portstewart, Glenhead, Glenleslie, Threetowns, and Forked Bridge in the Braid district, Culbane, Co. Derry, &c.

In America, round Washington, Mr. W. H. Holmes has found workshops where American tribes had chipped down rounded boulders into leaf-shaped blades, not for use in that condition, but in order that they might more easily be carried to other sites to be manufactured into arrow- and spear-heads. Sir John Evans, 'Ancient Stone Implements,' 2nd edit., p. 35, mentions a find of thirty-four such objects as I have described from Old Deer, Aberdeenshire. Dr. Munro, 'Prehistoric Scotland,' p. 357, mentions a similar hoard of 'thirty-four flints worked roughly to a leaf shape,' and another is described by Dr. Joseph Anderson, as 'A deposit of flints worked to a leaf shape found at Bulwark, Old Deer, Aberdeenshire.' These finds seem to be one and the same, and from the figures shown in

Dr. Anderson's paper I believe the objects to be similar to those which I have collected. He sums up in his paper that 'We have here the material partially manufactured, roughly blocked out for arrow- and spear-heads, so treated that they could easily be transported to a distance.'

That these rough Irish specimens represent, therefore, a stage in the manufacture of spear- and arrow-heads, I have no doubt, and they seem to form a series from the rude to a more highly finished state.

5. *On a recent Discovery of Palæolithic Implements in Plateau Gravels of Ipswich. By* MISS NINA F. LAYARD.

The deposit in question appears to have been formed under post-Glacial conditions, somewhat resembling those which obtain at Hoxne. The area hitherto examined does not exceed 53 feet by 30 feet, but it has yielded twenty-seven implements representing fifteen distinct varieties, a fairly complete assortment of palæolithic types. Pointed implements predominate; the majority conveniently humped for holding, but one sharpened at the butt, so that it could not have been held comfortably unless hafted. Two other implements show depressions which might have received a haft. The clumsier tools would appear to have been specially fitted for agricultural purposes.

One implement seems to show traces of previous working, for the flint was already of the desired shape before its thick white coating was formed.

6. *On a recent Find of Palæolithic Flint Implements at Knowle, Wiltshire. By* WM. CUNNINGTON, *F.G.S., and* WM. A. CUNNINGTON, *Ph.D.*

In a gravel-pit near Knowle Farm, on the borders of Savernake Forest, Wiltshire, there have been found within the last year and a half a large number of palæolithic flint implements. Some are very cleverly flaked, in this respect almost resembling neoliths, whilst others are exceedingly rude, almost shapeless, and difficult to recognise as having been wrought by man. In connection with the implements, as indeed with the unworked flints from the same locality, two interesting and somewhat difficult problems arise. The flints, worked and unworked alike, are in some cases (about 10 per cent. of the whole) scratched in a remarkable manner, either all over or on the more exposed areas. The scratches appear in some cases to have been more or less filled up by a later deposit of white silica. Various suggestions have been made to account for the scratching, but the authors believe it could only have been accomplished by glacial agency. If the markings be accepted as glacial striæ, we have here further evidence of the existence of man on the earth in pre-Glacial or inter-Glacial times. A further remarkable feature exhibited by many of the flints is their highly glazed or polished state. The flints are seldom completely polished, but have polished areas of varying size, often corresponding to the more exposed regions. Bands of varying hardness show varying degrees of polish, and the high gloss is most frequently produced upon lately fractured surfaces. Certain authorities have attributed the extremely glossy surface to a secondary deposition of silica locally whilst the flints were embedded in the gravel. The authors, however, believe the effect to have been produced by blown sand, presumably very fine sand, the action being in all probability assisted by the presence in it of a considerable percentage of iron oxide.

7. *Notes on the Excavation of a Primitive Site near Groomsport, Co. Down. By* ROBERT M. YOUNG.

This Paper describes the remains of a primitive settlement discovered by the author in July 1897 on the Co. Down coast.

1. The site was adjacent to the sea, beneath a grass-grown field, formerly a

sand dune. At a depth of several feet were found a number of burnt clay hearths, about 1 foot in diameter, surrounded with charcoal and burnt stones.

2. There were numerous fragments of bones which had been broken to extract the marrow. Professor R. O. Cunningham has identified a small species of deer, boar, and probably goat. Shells of limpet and periwinkle of unusual size occurred in masses, and whelks, mussels, scallops, and cockles sparingly.

3. The principal relics found comprised a bronze pin, an amulet of flint with natural perforation, burnt clay food-vessel simply incised, and numerous implements of schistose slate.

4. From the appearance of the deposit now covering the ancient ground-surface the author is of opinion that it has been probably deposited by the sea, which would have required to rise at least 10 feet above its present highest level to do so.

8. *On the Occurrence in Ireland of Objects of Hallstatt Types.*
By G. Coffey.

The author noted the frequent occurrence in Ireland of bronze swords of the type of Plate V. 7 of von Sacken's 'Graberfeld von Hallstatt,' and illustrated details of their points and handle-plates. Scabbard chapes also occur, like those in De Mortillet, 'Museé Préhistorique,' Plate XCVI. The Irish examples of caldrons like von Sacken, Plate XX., were probably imported, and appear to have influenced the forms of the pottery; round-bottomed caldrons also occur. Pointed rivet-heads, and twisted stay-rods, like von Sacken, Plates XXIII.–XXIV., and embossed and corrugated metal-work, often with concentric-circle ornament, supply further correspondences; so also certain pins, chains, pendants, and other miscellaneous objects. Iron was probably known before the close of the Hallstatt period in Ireland; and early 'La Tène' monuments have been noted.

9. *Report on Explorations in Crete.*—See Reports, p. 466.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Reports and Papers were read:—

1. *Report on Anthropometric Investigations among the Native Troops of the Egyptian Army.*—See Reports, p. 350.

2. *Note on a Method of Radial Craniometry.* *By* C. S. Myers, *M.D.*

3. *Measurements of the Indian Coronation Contingent.*[1] *By* J. Gray, *B.Sc.*

These measurements were made at the camp of the Indian contingent at Hampton Court. About nineteen different racial groups from all parts of India, except Eastern Bengal, were represented. The number of persons in each group varied from six to eighteen. The maximum length and breadth of the head and the stature were measured in each case. The average dimensions of each group and the standard deviations of these dimensions have been calculated. The results are given in the annexed table. When the groups are plotted out on a chart, using the average length and breadth of head as co-ordinates, they arrange themselves in five main divisions: I. The North-West Frontier or Mongolian; II. The Northern Plain or Aryan; III. The Himalayan; IV. The Eastern Deccan; V. The Western Deccan. Division I., represented by the Baluchis, is characterised by a very short and broad head, and is quite distinct from all the other Indian races. The Aryans (Division II.) are very long-headed. The Himalayan (Division III.) and the Dravidian (Division IV.) are almost exactly alike in head dimensions, pointing to the conclusion that they both belonged to the same pre-Aryan race, and were separated by the Aryan invasion. The inhabitants of the Western and Central Deccan (Division V.) have much shorter heads than the Eastern Dravidians, which points to an immigration on the west coast of a Mongolian race by sea, or by land from Persia or Baluchistan. The smallest deviations are exhibited by the highest castes, such as the Brahmans and the Rajputs, and by geographically isolated races such as the Dogras, Goorkhas, and Pathans; and the greatest deviations by Mohammedans and Sikhs, where caste does not exist to prevent admixture with other races.

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[1] Published in full in *Man*, 1903.

Table of Measurements and Deviations.

Racial Groups	Number of persons	Head lengths		Head breadths		Stature				Cephalic indexes
		mm.	Deviation per cent.	mm.	Deviation per cent.	mm.	ft.	in.	Deviation per cent.	
I. North-Western Frontier or Mongolian.										
Baluchis	13	186	4·27	155	3·1	1749	5	9	3·26	83·4
II. Northern Plain or Aryan Races.										
Brahmans	7	200	1·32	147	1·96	1796	5	10¾	1·58	73·5
Afridis	18	198	3·39	147	3·80	1769	5	9¾	1·50	74·5
Pathans or Afghans .	15	193	3·86	148	2·16	1782	5	10¼	3·27	76·3
Punjab Mohammedans	9	202	2·75	147	3·4	1819	5	11½	1·9	72·7
Sikhs	16	197	3·64	144	3·99	1800	5	11	2·66	73·1
Jats	6	199	3·16	145	3·4	1823	5	11¾	1·17	73·0
Rajputs, Hindu . .	6	195	2·52	147	3·2	1786	5	10¼	1·98	75·4
„ Mohammedan	7	198	3·45	145	2·63	1825	5	11¾	1·42	73·2
„ Marwari .	10	194	2·94	147	3·63	1802	5	11	2·19	75·8
Dogras	6	194	1·46	144	2·20	1750	5	9	1·26	74·2
III. Himalayan Races.										
Goorkhas . . .	6	191	1·81	145	2·85	1679	5	6	1·35	75·4
Garhwali . . .	6	190	2·18	144	4·4	1649	5	5	2·46	75·9
IV. Eastern Deccan.										
Mohammedans . .	6	196	3·98	144	5·43	1708	5	7¼	2·30	73·5
Tamils, Madras . .	6	191	4·14	144	2·40	1740	5	8½	3·15	75·4
V. Western and Central Deccan.										
Hyderabad contingent .	6	186	3·13	145	4·36	1807	5	11¼	0·63	78·0
Mahrattas . . .	7	186	3·99	147	3·36	1740	5	8½	1·15	79·0
Moplas . . .	6	186	2·77	144	5·35	1725	5	8	2·25	77·5
Averages . . .	—	—	3·04	—	3·20	—	—		1·97	—

4. *Note on some Measurements of Eskimo of Southampton Island.*
By J. F. Tocher, *F.I.C.*

5. *Report on the Pigmentation Survey of the School Children of Scotland.*—See Reports, p. 352.

6. *On the Mental and Moral Characteristics of the People of Ulster.*
By William Graham, *M.D.*

By the term 'Ulsterman' is here meant not any or every inhabitant of Ulster, but only that element in the population which derives its descent from the Scotch and English colonists of the Plantation under James I. Ulster in this narrow sense really means little more than the counties of Derry, Antrim, Down, and Armagh. The main elements which have gone to the making of the Ulsterman are as follows:—(1) The foundation is lowland Scotch. In parts of Antrim there may be seen the descendants of a still earlier emigration into the country from the Celtic Western Isles of Scotland; but this element is small, and may be disregarded. The colonists from Dumfries and Ayrshire were the really determining factors in the creation of the modern Ulsterman. (2) A very considerable English leaven which coalesced with the Scotch settlers; this element is especially to be noted in counties Armagh and Fermanagh. (3) An infusion of French blood, due to the Revocation of the Edict of Nantes, for it was under Louis Crommellin, the Huguenot leader, that the linen industry was established, which has lain at the root of Ulster prosperity. Here we may find the source of a certain vivacity which distinguishes the Ulsterman from the lowland Scot.

Two qualities the Ulsterman owes to his Scotch blood: (*a*) his self-reliance and independence, liable at times to degenerate into rudeness; (*b*) his ultra-religiousness. He is in creed a Calvinist of the most uncompromising type. He differs, however, from the Scot in other points: (1) he is not so 'dour,' he is more genial and human; (2) he is not particularly clannish, and owing to his history as a settler in a strange land he has assumed a certain cosmopolitan tinge; (3) he is more adaptable than the lowland Scot; he takes on the culture, and accommodates himself at once to the customs, of another country.

Again, he is to be distinguished from the Celtic Irish as follows:—(*a*) In modes of speech and habits of thought. There are many provincialisms peculiar to Ulster. A few may be given: 'carnaptious' = ill-tempered; 'dunt' = blow; 'dunsh' = push; 'spuds' = potatoes; 'wheen' = a quantity; 'girn' = grin; and 'oxther' = armpit. (*b*) The Celt is a poetic and unpractical person; the Ulsterman is nothing if not utilitarian. He cares nothing for the æsthetic. Solid comfort, plain practical ends, are what he aims at. (*c*) The Celt is loyal to persons—leaders in Church and State; the Ulsterman is loyal to institutions. (*d*) The Celt is an aristocrat in disposition; the Ulsterman, whatever may be his theory, is in practice a democrat. Hence (*e*) the Celt has grace, pliancy, and inborn susceptibility to beauty and refinement; while the Ulsterman is hard, self-assertive, and somewhat rude. (*f*) The Celt has humour; the Ulsterman has wit. Humour is fantastic, governed by no law save the waywardness of fancy; wit in Ulster is sharp, biting, cynical, with strong affinities to the type prevailing in Scotland. The form of humorous speech known as 'bulls' is unknown in Ulster. (*g*) The Celt is a sportsman, and takes his pleasures gaily; the Ulsterman cares nothing for hunting, racing, the fine arts, opera, or the dance. The latter, as has been said, is thoroughly utilitarian. He eschews amusements, and gives himself wholly to work.

There is a form of insanity which in Ireland is peculiar to Ulster—that arising from religious causes. At intervals epidemics of this form of brain disorder have swept through the country, notably in 1859. Tables are appended to this Abstract from which it may be found—(1) That religion as a factor in the causation of insanity is confined to the Protestant population; Roman Catholics are not much affected by it. (2) That general paralysis of the insane is practically unknown in the rural communities of Ulster. It is in Belfast we find it. (3) In Co. Armagh religion as a cause falls into the background. This is probably owing to the fact that the settlement was originally English, and hence not so intense in religion as the neighbouring Scotch people. (4) Paradoxical though it be, that in Belfast insanity increases in proportion as trade prospers—while the contrary holds good of the country districts. The explanation seems to be that increased wages in the city leads to increased indulgence in drink and other vices; whereas in the country the burden of poverty, always felt in some degree, unhinges the mind when times are specially bad.

It may be added that one of the main preventible causes of insanity in Ulster is the prevailing lack of amusements and recreations. Of an intensely religious nature by heredity, the Ulsterman has no counterbalancing aptitudes which might rectify abnormal brain reactions.

I. *Return of Admissions of Patients to the District Lunatic Asylums named, due to 'Religious Excitement' during the years* 1890 *to* 1900 *inclusive.*

Year	Belfast and Antrim		Armagh		Down		Londonderry		Total Religious Excitement Cases		Total Admissions	
	Religious Excitement Cases	Total Admissions	Religious Excitement Cases	Total Admissions	Religious Excitement Cases	Total Admissions	Religious Excitement Cases	Total Admissions	In the Four Counties	In all Ireland	In the Four Counties	In all Ireland
1890	10	200	—	94	4	152	1	98	15	80	544	3,095
1891	16	203	—	95	6	145	4	93	23	78	536	3,010
1892	13	216	—	115	3	140	1	103	17	59	574	3,181
1893	10	210	1	94	3	117	1	109	15	60	530	3,207
1894	16	215	2	112	—	159	4	96	22	59	582	3,229
1895	15	240	3	95	—	138	1	81	22	49	554	3,216
1896	22	273	4	86	3	128	4	97	33	62	584	3,329
1897	10	236	3	91	—	115	5	97	18	49	539	3,285
1898	15	289	8	96	3	126	7	81	33	60	592	3,469
1899	9	334	1	89	2	128	7	82	19	46	633	3,549
1900	12	436	—	79	2	149	4	81	18	39	745	3,546
Totals	148	2,852	22	1,046	26	1,497	39	1,018	235	641	6,413	36,116

OBSERVATIONS.

Percentage of Religious Excitement Cases on the Total Admissions:—

(1) In the four Asylums	3·7
(2) In All Ireland	1·8
(3) In Belfast and Antrim	5·2
(4) In Armagh	2·2

Population:—

	1891	1901
Four Counties	990,485	1,020,142
All Ireland	4,704,750	4,456,546
Belfast City	255,922	348,876

II. *Return showing Admissions of Patients to the District Asylums named, suffering from 'General Paralysis of the Insane,' for the period from* 1890 *to* 1900 *inclusive.*

Year	Belfast and Antrim	Armagh	Down	Londonderry
1890	4	—	3	—
1891	3	—	—	—
1892	5	1	—	—
1893	3	1	5	—
1894	2	—	6	—
1895	1	—	2	—
1896	8	1	3	—
1897	8	1	2	—
1898	6	1	2	—
1899	12	—	4	—
1900	14	—	3	—
Totals . .	66	5	30	0

7. *A Study in the Psychology of Primitive Man. By* A. AMY BULLEY.

Sufficient information is now available with regard to primitive man to afford a general view of the trend of his ideas. We are thus enabled to estimate his intellectual calibre, and ascertain which among the mental processes he carried on with ease, and which were feebly and tentatively performed. Perfect certainty cannot be attained, but the results of the survey should be useful in testing the correctness of theories crediting primitive man with particular ideas and beliefs. *Negative* conclusions only are aimed at here. By ascertaining the limits of primitive man's intellectual powers we can rule out theories as to his beliefs which are incompatible with his actual stage of development. If found weak in certain mental processes he cannot be reasonably credited with conceptions implying their free working.

Investigation does not warrant us in attributing any absolute mental deficiency to primitive man. He appears to have been capable of all mental processes. The higher and more complex processes, however (ideation, analysis, synthesis, and the formation of complex concepts), were performed with facility only when concerned with the details of daily life and the struggle for existence. Where these were not present the higher processes were but imperfectly performed. In the world of abstract ideas we must predicate for primitive man, as for his descendants, a considerably lower level than in the practical world.

The most conspicuous failing in primitive man was inability to differentiate. He perceived similarities rather than differences, the latter involving clearer perception, and being therefore a later product of the intelligence. Things which were alike were to him identical, or at least equivalent. To employ the terminology of Principal Lloyd Morgan, he 'sensed' objects singly, and without anything more than a hazy perception of their relation to one another.

The results of this deficiency were:—

1. Inability to generalise.
2. No distinction recognised between essential and non-essential characteristics.
3. Imperfect understanding of cause and effect.

1. Generalisation demands differentiation, the analysis of separate qualities, and their re-combination in a new concept covering a wide field of observation. These processes primitive man could only perform imperfectly.

2. A mental stumbling-block too familiar to need explanation. It is not wholly unknown in more advanced times.

3. Observation and induction, leading up to the correct inference of cause and effect, demand a sustained mental effort of which primitive man was incapable. He accepted as cause and effect any set of phenomena commonly or strikingly associated in his experience. On the other hand, he failed to perceive cause and effect in the simplest and most universal biological processes or physical sequences. It is doubtful further whether, as Dr. Frazer thinks, he had grasped the idea of the universality of Nature involved in the inference of cause and effect.

Since all human ideas must have passed through the stage characterised by the deficiencies just mentioned, we may apply the test to certain theories of the origin of religious ideas:—

1. One Supreme God.—We may safely assert that primitive man was incapable of the abstraction and generalisation requisite for forming the idea of one Supreme God, omnipotent and universal, distinct and separate from humanity—the Creator of the world.

2. Phallic worship.—If not otherwise discredited as an origin, phallic worship would have to be ruled out for similar reasons. Primitive man was incapable of mentally isolating a single faculty or power sufficiently to exalt it for worship.

3. The 'ghost theory' demands a more distinct conception of personality and a clearer realisation of the ideas of life and death than primitive man possessed. He had not reached the belief in death from natural causes, and the personality of a deceased man might, to his thinking, be re-incarnate in his descendants.

4. Dr. Jevons's theory of the *continuum* in religion implies the existence of a single clear, persistent perception dissociated from the general stock of primitive ideas, and apparently on a higher level.

The absence of clear and distinct ideas on any subject in the early stages of development makes it improbable that any single idea whatever is to be regarded as the origin of religion. Probably a number of separate ideas combined later, but all theories on this subject must be in harmony with the general stage of primitive development so far as ascertained.

8. *On the Lolos and other Tribes of Western China.*

By Augustine Henry.

The Paper describes (1) the various *Tibetan* tribes on the western border of Szechuan; (2) the migratory *Miao-tze* from Kweichow, whose tonal monosyllabic language has a vocabulary distinct from that of the other languages of that group; (3) the *Yaos*, a farming and hunting people who are probably the aborigines of Kwangsi, and inhabit isolated villages from *Kwangsi* to *Szemao*, and also dwell in French Laos; (4) the *Shans* of the low-lying plains of South Yunnan and Upper Burma, who are akin to the Siamese; (5) the dark swarthy *Woni*, a very uniform-featured people, aboriginal south of the Red River of Yunnan; (6) the diminutive *Pula*, 4–4½ feet in stature, who speak a dialect of Lolo, and are regarded as wizards by the Chinese; and whose love of gay clothing, and lively temperament afford further parallels to the traditions of a diminutive fairy-folk, which Dr. Rhys has collected in Western Europe.

In addition to these, the paper describes (7) the *Lolos*, a tall handsome people, whose home is in Szechuan, but who are found all over Yunnan and in a few districts in Kweichow. Their language is tonal and monosyllabic, and the author contends that a comparison of Lolo and Miao-tze speech with Chinese shows that the tonal monosyllabic languages form a distinct primitive group, and are not the result of breaking down a polysyllabic agglutinative language.

The peculiar script of the Lolos is described and discussed. Though of hieroglyphic character it is not derivative from the Chinese script. It runs in vertical columns from *left* to *right*. The analogy of the later Syriac script suggests that this peculiarity may be due to early Nestorian missionaries, who had settlements in Yunnan as early as the time of Marco Polo.

The paper further describes the religious beliefs, elaborate animistic beliefs, cosmogony, ceremonies and rituals, songs and literature, and social organisation of the Lolos. Their surnames always signify the name of a tree or animal, or both tree and animal; and these are considered as the ancestors of the family bearing the name. To ask a man his name, the question is, 'What is it you do not touch?' but no worship is paid to the plant or animal.

9. *On the Wild and Civilised Races of the Malay Peninsula.*
By NELSON ANNANDALE *and* H. C. ROBINSON.

The Paper describes the districts which were visited by the authors, the investigations undertaken, and the material obtained.

I. The *civilised tribes* are as follow:—

1. *Malays and Siamese of the district between Singora and Jambu.*—Physical differences between the two are slight or absent; there is evidence of an admixture of aboriginal blood, though the aborigines are now practically extinct in the district. The general customs and mode of life are described. Two distinct physical types are to be recognised, but neither can be associated with one people or the other. Mahommedan and Buddhist customs are noted. The amusements, opium-smoking, diseases, and modes of burial are described.

2. The *South Perak Malays* are distinct from the people of Patani; their standards of civilisation more Occidental, but their race is non-persistent, being swamped by immigration.

3. In *Selangor* there is no long-established Malay population.

4. The *Samsams of Trang* are identical with or nearly related to the Malays o Upper Perak, but certain physical differences from the Malays of South Perak are noted, and their language, religion, and weapons are described.

II. The *savage tribes* are the following:—

5. *Semangs.*—Their distribution, social status, physical characters, and mode of life are described.

6. *Sakais.*—Their distribution and relationship to Semangs are noted, and their mode of life, external relations, and burial customs.

7.—*Orang Laut Kappir of Trang.*—Their possible relationships are discussed, with their dialect, religion, and customs.

TUESDAY, SEPTEMBER 16.

The following Papers and Reports were read:—

1. *The Lia Fáil of Tara, and Election of Kings by Augury.*
By E. SIDNEY HARTLAND.

The famous *Lia Fáil*, or Stone of Destiny, often identified with the Coronation Stone, 'was a stone on which were enchantments, for it used to roar under the person who had the best right to obtain the sovereignty of Ireland at the time of the men of Ireland being in assembly at Tara to choose a king over them.' It was thus an oracle; and the choice of king was made by the augury which it gave. Other modes of augury were also used in Ireland for this purpose, as well as in many savage and semi-civilised countries. Examples of these are cited from stories, as embodying real traditions of customs once prevalent. Kingship was something more than human. It was necessary, then, to ascertain the will of the gods. The practice in Central Africa; Melchizedek; the testimony of Homer; the ancient kings of Rome; changes in custom and oral tradition; the diagnosis of blood royal by animals and other means.

2. *On Perforated Stone Amulets.* *By* F. T. Elworthy, *F.S.A.*

There is a widespread belief in the efficacy of naturally perforated stones as prophylactic agents against witchcraft. Examples are given of :—

(1) Witchstones in a garden and against a door in Lincolnshire.

(2) The preservation of these stones as family possessions. In all cases the root idea is the need of protection against the Evil Eye.

(3) The prevalence of the belief in the susceptibility of cattle, and in 'witch doctors.'

(4) The so-called 'holy flints,' used chiefly in gardens in England, but also worn on the person, and employed by Dorset boatmen as protectors.

(5) A much-worn stone from Antrim used to protect cattle. This amulet has not only been tied upon cows' necks, but has been boiled in water for the cows to drink.

(6) Many specimens from Southern Italy, where they are also found on cow-houses, though chiefly, as in Lincolnshire, on dwelling-houses.

(7) A round piece of sea-worn pottery, with a central hole, from a house in South Italy, almost identical with a similar object in Bohemian glass, made as a trade article for East Africa.

That the perforation rather than the material is the real seat of the ideal value is proved by evidence from various localities, but particularly from modern Somerset. The question is raised of the connection of holed pebbles with the well-known larger apertures in rocks and boulders.

3. *Note on Two Japanese 'Bokŭ-to.'* *By* E. S. Hartland.

The author exhibits two *bokŭ-to*, or wooden swords, formerly worn as professional emblems by medical practitioners in Japan. One of them is shaped as a bean-pod containing seven seeds and adorned, near the ends, with representations in lacquer of a grasshopper and four other insects. The other is a rough piece of willow, on one side of which are cut Japanese characters meaning spider-boat. This name is connected with a Japanese legend. Attached to the *bokŭ-to* in question is a natural seed-vessel, or fig, for the purpose of retaining it in the girdle.

4. *On Tallies.* *By* E. Lovett.

Tallies are records kept by cutting notches in sticks of wood, and are a survival of probably the earliest appliance of a commercial nature made by man. The collection of these objects which is exhibited, a list of which is given below, is of special interest from the fact that the specimens have been in actual use, either quite recently or within the last twenty years or so. They represent two classes of tally, viz. (1) The *contract tally*, formed by a split stick (through the notches), each portion of which is retained by the two contracting parties respectively—a most effective and safe instrument. (2) The *simple* or *memorandum tally*, represented by single slips of wood upon which are recorded, by a series of notches of various form or arrangement, the intentional record of the operator. This latter form is of wide geographical distribution and of great antiquity; tallies of ivory, bone, and horn having been found in the cavern deposits of France. It is interesting to note that whereas the *simple* or *folk tally* has survived, the complex form, as elaborated in the bankers' and Exchequer tallies, has become quite obsolete, and now only exists in the form of our present commercial terms and expressions, all of which refer to the wooden instrument and *not* to its documentary successor. Even the word *tally* itself, which is derived from the French word 'to cut a notch,' is now taken to mean 'to agree, or balance amounts.'

To-day tallies are used in some of the hopfields of Kent and Worcestershire; very extensively by the bakers of Normandy and some other parts of France; in the vineyards of the valley of the Gironde; and here and there by farmers, gamekeepers, and wood-cutters in some of the rural districts of our own islands. Naturally, too, they are found in various simple forms in use by the aborigines of foreign countries, and the museums of the Continent contain many examples from various deposits of prehistoric age.

The specimens exhibited include:—Hop tally (and counters), Kent and Worcester; bakers', Normandy and Holland; brewers', Isle of Man and Berlin; snow, Vienna; fishing, Tain (N.B.); vineyard, Gironde (France); farmers' lamb, Worcester; gamekeepers' and faggot-makers', Norfolk; curling, Scotland; journey, Blantyre (B.C. Africa); carters', Sussex and Worcester; labour, Beauly (N.B.).

5. *Report on the Age of Stone Circles.*—See Reports, p. 455.

6. *Preliminary Note on a Prehistoric Cemetery-cave in Palestine.*

By R. A. STEWART MACALISTER, *M.A.*

In the excavation at present in progress on behalf of the Palestine Exploration Fund at the site of the ancient city of Gezer an important discovery has just been made. Overlaid by *débris*, which may tentatively be dated about 2000 B.C., the mouth of a cave about 30 feet long was found. This cave proved to have been artificially cut out to serve the purpose of a crematorium. The floor was strewn, in some cases thickly covered, with the remains of human bodies, which had been burnt where they lay. A chimney was cut in the rock to provide the draught necessary for the fire. At a later time the cave was again used, this time for the interment of unburnt bodies, many of which were scattered (in a contracted position) over the floor, a few being deposited in enclosures separated by rude walls from the rest of the cave.

Large numbers of food-vessels, of early types, were found associated with both strata of remains.

The bones were examined by Professor A. Macalister. They are so broken and injured that satisfactory measurements of a few only could be made. However, they are distinguished into two well-marked types.

The *burnt* bones are those of people of slender build, and small but not dwarfish stature—none over 5 feet 7 inches, most under 5 feet 4 inches. Limbs slender but muscular; no perforated humeri, a few slightly platycnemic tibiæ, a few platymeric, but no pilastered femora. Cranial shape an elongated oval, fairly well arched longitudinally, but rather flat-sided, with length-breadth index about 72 to 75. Skull bones thick and heavy.

The *unburnt* bones belong to a taller race—average height 5 feet 6 inches (maximum 5 feet 11 inches) in males, 5 feet 4 inches in females. Limbs stronger and larger-boned, platycnemic tibiæ, pilastered femora. Squatting facets on leg joints well developed. Skulls larger, of thinner bones, pentagonoid both when viewed from above and from behind. Length-breadth index about 78.

This is the first discovery yet made of bones belonging to the pre-Israelite inhabitants of Palestine. The unburnt bones belong apparently to the earliest Semite stock, their predecessors to a pre-Semite and possibly aboriginal race.

A full account of this discovery, with illustrations, appears in the 'Quarterly Statement' of the Palestine Exploration Fund for October 1902.

7. *On a Survival of certain Pagan Sepulchral Symbols on Early Christian Monuments in Ireland.* *By* P. J. O'Reilly.

The writer points to the existence of cup-marks and inscribed single circles and concentric circles in the earlier, and cup-and-concentric circles in the later, of the Irish pagan tumuli, and presents photographs of a series of Christian sepulchral monuments found in the cemeteries of ancient churches, all of which were probably founded in or before the seventh century, and are situated in the limited area of the half-barony of Rathdown, Co. Dublin. These monuments include cupped stones at Dalkey, Tully, and Rathmichael; stones presenting a cupped medial-band design at Rathmichael and Killegar; others at Cruagh and Rathmichael bearing cup-and-concentric-circle designs; others at Killegar and Rathmichael exhibiting the latter design in combination with a radiating triple-line design; a cupped 'fish-bone' design at Rathmichael; and combinations of the cup-and-concentric-circle and 'fish-bone' designs at Ballyman and Tully. Among facts stated which show that these Rathdown designs were wrought at a later period than their pagan prototypes, and that the stones bearing them are not pagan sepulchral monuments utilised as memorials of Christian dead, is the existence on one at Dalkey of a symmetric combination of two cup-and-concentric-circle groups and four single circles with an incised cupped Irish wheel-cross that is undeniably of Christian origin and contemporaneous with the remainder of the design, which forms a valuable link between the pagan-like patterns of the earlier members of the series and the free standing crosses of the district, four of which bear the single-circle symbol.

8. *Report on the Excavations in the Roman Fort at Gellygaer.*

See Reports, p. 450.

9. *Report on the Excavations of the Roman City at Silchester.*

See Reports, p. 453.

10. *On the Khami Ruins, near Bulawayo, Rhodesia.*

By F. P. Mennell, *F.G.S., Curator of the Rhodesia Museum.*

All over the territory between the Zambesi and the Limpopo, now known as Southern Rhodesia, are numerous structures which testify to a former occupation of the country by a race far more advanced in the arts than the Bantu tribes, who are shown by Arab records to have inhabited the country for fully two thousand years. The Khami Ruins, situated twelve miles from Bulawayo, may be taken as typical. They consist of about a dozen separate structures showing the usual mortarless walls faced with carefully squared granite blocks about twice as large as an ordinary brick. These walls are about 3 feet thick, and rise perpendicularly without any batter, as a rule, to heights of 10 to 20 feet or more. The exterior walls roughly conform to the shape of the ground available, or are more or less circular, but the interior ones ramify about in a most intricate manner. The principal ruin has three sets of walls at different levels; and as the spaces which they enclose have become filled with débris, they give the hill on which they are built a terraced appearance. The main entrance to this structure has square ends to the walls on either side, and recent excavations have revealed the fact that a series of stone-built steps lead up to it from the foot of the slope. In other cases the walls are rounded off at the entrances, and rounded buttresses support them at times. Other devices in the way of decoration are the 'chess-board' and 'herring-bone' patterns, formed by varying the positions of the facing blocks and the introduction of dark-coloured dolerite blocks to contrast with the granite.

It has been stated that these structures could not have been roofed in, and in only one instance (Impateni) out of many hundreds is a covered entrance known.

At Dhlo Dhlo Ruins, however, there are the remains of wooden posts let into the masonry, and these have now been found at Khami also. It seems possible that they may have been intended, in some cases at least, as supports for a roof. That the buildings were intended primarily as forts may be inferred from their inaccessible situations, their narrow and well-commanded entrances, and the fact that the sides of some of the hills on which they are built have evidently been artificially steepened.

Many objects of interest have been discovered at Khami, most of which are now in the Rhodesia Museum, Bulawayo. The pottery and the articles made of copper and iron are probably in nearly all cases the work of later occupants of the ruins than the builders. Discrimination is rendered difficult by the obvious fact that the natives have copied the designs of the earlier workers. This may indicate either that they are the degenerate descendants of the builders of these remarkable structures, or that their ancestors were forced to work for the latter as slaves. The second is in all probability the correct explanation. Peculiar flat oval-shaped stones, sometimes pierced with a hole near one end, are among the articles which may be regarded as ancient, and so are the numerous gold ornaments. The latter include chain- and wire-work, tacks for fastening beaten gold on to wood, and gold beads of all shapes and sizes and in every stage of manufacture. A few pieces of tin found in one of the smaller structures are of interest, as the metal does not appear to occur anywhere in Rhodesia. They may have been imported. Two classes of objects are conspicuous by their absence here, as at all the other ruins. These are inscriptions of any kind, and iron tools such as must have been used in dressing the stone for building. The latter may well have rusted away during the thousands of years which have almost certainly elapsed since they were laid aside, but the absence of the former is not so easy to explain, if these structures are the work, as has been contended, of the Sabæans of Arabia.

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11. *On the Ethnography of the Nagas.* *By* W. H. FURNESS, *M.D.*

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12. *Demonstration on the Specimens in the Anatomical Museum which illustrate points in Physical Anthropology.* *By* Professor J. SYMINGTON, *M.D.*

WEDNESDAY, SEPTEMBER 17.

The following Papers and Reports were read:—

1. *Excavations at Palæokastro in Eastern Crete.*

By R. C. BOSANQUET, *M.A.*

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2. *Report on the Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest.*—See Reports, p. 449.

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3. *Report on the Organisation of an Ethnological Survey of Canada.*

See Reports, p. 353.

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4. *On the Classification and Arrangement of the Exhibits in an Anthropological Museum.* *By* W. H. HOLMES.

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5. *Suggestions for the Classification of the Subject-matter of Anthropology.* *By* E. N. FALLAIZE, *B.A.*

SECTION I.—PHYSIOLOGY

PRESIDENT OF THE SECTION—Professor W. D. HALLIBURTON, M.D., F.R.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

The Present Position of Chemical Physiology.

AN engineer who desires to thoroughly understand how a machine works must necessarily know its construction. If the machine becomes erratic in its action, and he wishes to put it into proper working order, a preliminary acquaintance with its normal structure and function is an obvious necessity.

If we apply this to the more delicate machinery of the animal body we at once see how a knowledge of function (physiology and pathology) is impossible without a preliminary acquaintance with structure or anatomy.

It is therefore not surprising, it is indeed in the nature of things, that physiology originated with the great anatomists of the past. It was not until Vesalius and Harvey by tedious dissections laid bare the broad facts of structure that any theorising concerning the uses of the constituent organs of the body had any firm foundation.

Important and essential as the knowledge is that can be revealed by the scalpel, the introduction and use of the microscope furnished physiologists with a still more valuable instrument. By it much that was before unseen came into view, and microscopic anatomy and physiology grew in stature and knowledge simultaneously.

The weapons in the armoury of the modern physiologist are multitudinous in number and complex in construction, and enable him in the experimental investigation of his subject to accurately measure and record the workings of the different parts of the machinery he has to study. But pre-eminent among these instruments stands the test-tube and the chemical operations typified by that simple piece of glass.

Herein one sees at once a striking distinction between the mechanism of a living animal and that of a machine like a steam engine or a watch. It is quite possible to be an excellent watchmaker or to drive a steam engine intelligently without any chemical knowledge of the various metals that enter into its composition. In order to set the mechanism right if it goes wrong all the preliminary knowledge which is necessary is of an anatomical nature. The parts of which an engine is composed are stable; the oil that lubricates it and the fuel that feeds it never become integral parts of the machinery. But with the living engine all this is different. The parts of which it is made take up the nutriment or fuel and assimilate it thus building up new living substance to replace that which is destroyed in the wear and tear associated with activity. This condition of unstable chemical equilibrium is usually designated metabolism, and metabolism is the great and essential attribute of a living as compared with a non-living thing.

It seems childish at the present day, and before such an audience as this, to point out how essential it is to know the chemical structure as well as the anatomical structure of the component parts of the body. But the early anatomists to whom I have alluded had no conception of the connection of the two sciences. Speaking of Vesalius, Sir Michael Foster says: 'The great anatomist would no doubt have made use of his bitterest sarcasms had someone assured him that the fantastic school which was busy with occult secrets and had hopes of turning dross into gold would one day join hands in the investigation of the problems of life with the exact and clear anatomy so dear to him.' Nor did Harvey, any more than Vesalius, pay heed to chemical learning. The scientific men of his time ignored and despised the beginning of that chemical knowledge which in later years was to become one of the foundations of physiology and the mainstay of the art of medicine.

The earliest to recognise this important connection was one whose name is usually associated more with charlatanry than with truth, namely, Paracelsus, and fifty years after the death of that remarkable and curious personality his doctrines were extended and developed by van Helmont. In spite, however, of van Helmont's remarkable insight into the processes of digestion and fermentation, his work was marred by the mysticism of the day which called in the aid of supernatural agencies to explain what could not otherwise be fully comprehended.

In the two hundred and fifty years that have intervened between the death of van Helmont and the present day alchemy became a more and more exact science, and changed its name to chemistry, and a few striking names stand out of men who were able to take the new facts of chemistry and apply them to physiological uses. Of these one may mention Mayow, Lower, Boerhaave, Réaumur, Borelli, Spallanzani, and Lavoisier. Mulder in Holland and Liebig in Germany bring us almost to the present time, and I think they may be said to share the honour of being regarded as the father of modern chemical physiology. This branch of science was first placed on a firm basis by Wöhler when he showed that organic compounds can be built out of their elements in the laboratory, and his first successful experiments in connection with the comparatively simple substance urea have been followed by numberless others, which have made organic chemistry the vast subject it is to-day.

Sir Michael Foster's book on the History of Physiology, from which I have already quoted, treats of the older workers who laid the foundations of our science, and whose names I have not done much more than barely mention. Those interested in the giants of the past should consult it. But what I propose to take up this morning is the work of those who have during more recent days been engaged in the later stages of the building. The edifice is far from completion even now. It is one of the charms of physiological endeavour that as the older areas yield their secrets to the explorers new ones are opened out which require equally careful investigation.

If even a superficial survey of modern physiological literature is taken, one is at once struck with the great preponderance of papers and books which have a chemical bearing. In this the physiological journals of to-day contrast very markedly with those of thirty, twenty, or even ten years ago. The sister science of chemical pathology is making similar rapid strides. In some universities the importance of biological chemistry is recognised by the foundation of chairs which deal with that subject alone; and though in the United Kingdom, owing mainly to lack of funds, this aspect of the advance of science is not very evident, there are signs that the date cannot be far distant when every well-equipped university or university college will follow the example set us at many seats of learning on the Continent and at Liverpool.

With these introductory remarks let me now proceed to describe what appear to me to be the main features of chemical physiology at the present time.

The first point to which I shall direct your attention is the rapid way in which chemical physiology is becoming an exact science. Though it is less than twenty years since I began to teach physiology, I can remember perfectly well a time when those who devoted their work to the chemical side of the science might almost be counted on the fingers of one hand, and when chemists looked with scarcely veiled contempt on what was at that time called physiological chemistry: they stated that physiologists dealt with messes or impure materials, and therefore anything in the nature of correct knowledge was not possible. There was a good deal of truth in these statements, and if physiologists to-day cannot quite say that they have changed all that, they can at any rate assert with truth that they are changing it. This is due to a growing *rapprochement* between chemists and physiologists. Many of our younger physiologists now go through a thorough preliminary chemical training; and on the other hand there is a growing number of chemists—of whom Emil Fischer may be taken as a type—who are beginning to recognise the importance of a systematic study of substances of physiological interest. A very striking instance of this is seen in the progress of our knowledge of the carbohydrates, which has culminated in the actual synthesis of several members of the sugar group. Another instance is seen in the accurate information we now possess of the constitution of uric acid. When Miescher began his work on the chemical composition of the nuclei of cells, and separated from them the material he called nuclein, he little foresaw the wide practical application of his work. We now know that it is in the metabolism of cell-nuclei that we have to look for the oxidative formation of uric acid and other substances of the purine family. Already the chemical relationships of uric acid and nuclein have taught practical physicians some of the secrets that underlie the occurrence of gout and allied disorders.

With the time at my disposal, it would be impossible to discuss all the chemico-vital problems which the physiologists of the present day are attempting to solve, but there is one subject at which many of them are labouring which seems to me to be of supreme importance—I mean the chemical constitution of proteid or albuminous substances. Proteids are produced only in the living laboratory of plants and animals; proteid metabolism is the main chemical attribute of a living thing; proteid matter is the all-important material present in protoplasm. But in spite of the overwhelming importance of the subject chemists and physiologists alike have far too long fought shy of attempting to unravel the constitution of the proteid molecule. This molecule is the most complex that is known: it always contains five, and often six, or even seven elements. The task of thoroughly understanding its composition is necessarily vast, and advance slow. But little by little the puzzle is being solved, and this final conquest of organic chemistry, when it does arrive, will furnish physiologists with new light on many of the dark places of physiological science.

The revival of the vitalistic conception in physiological work appears to me a retrograde step. To explain anything we are not fully able to understand in the light of physics and chemistry by labelling it as vital or something we can never hope to understand is a confession of ignorance, and, what is still more harmful, a bar to progress. It may be that there is a special force in living things that distinguishes them from the inorganic world. If this is so, the laws that regulate this force must be discovered and measured, and I have no doubt that those laws when discovered will be found to be as immutable and regular as the force of gravitation. I am, however, hopeful that the scientific workers of the future will discover that this so-called vital force is due to certain physical or chemical properties of living matter which have not yet been brought into line with the known chemical and physical laws that operate in the inorganic world, but which as our knowledge of chemistry and physics increases will ultimately be found to be subservient to such laws.

Let me take as an example the subject of osmosis. The laws which regulate this phenomenon through dead membranes are fairly well known and can be experimentally verified; but in the living body there is some other manifestation of force which operates in such a way as to neutralise the known force of osmosis. Is it necessary to suppose that this force is a new one? May it not rather be that our much vaunted knowledge of osmosis is not yet complete? It is quite easy to understand why a dead and a living membrane should behave differently in relation to substances that are passing through them. The molecules of the dead membrane are, comparatively speaking, passive and stable; the molecules in a membrane made of living cells are in a constant state of chemical integration and disintegration; they are the most unstable molecules we know. Is it to be expected that such molecules would allow water, or substances dissolved in water, to pass between them and remain entirely inactive? The probability appears to me to be all the other way; the substances passing, or attempting to pass, between the molecules will be called upon to participate in the chemical activities of the molecules themselves, and in the building up and breaking down of the compounds so formed there will be a transformation of chemical energy and a liberation of what looks like a new force. Before a physicist decides that his knowledge of osmosis is final, let him attempt to make a membrane of some material which is in a state of unstable chemical equilibrium, a state in some way comparable to what is called metabolism in living protoplasm. I cannot conceive that such a task is insuperable, and when accomplished, and the behaviour of such a membrane in an osmometer or dialyser is studied, I am convinced that we shall find that the laws of osmosis as formulated for such dead substances as we have hitherto used will be found to require revision.

Such an attitude in reference to vital problems appears to be infinitely preferable to that which too many adopt of passive content, saying the phenomenon is vital and there is an end of it.

When a scientific man says this, or that vital phenomenon cannot be explained by the laws of chemistry and physics, and therefore must be regulated by laws of some other nature, he most unjustifiably assumes that the laws of chemistry and physics have all been discovered. He forgets, for instance, that such an important detail as the constitution of the proteid molecule has still to be made out.

The recent history of science gives an emphatic denial to such a supposition. All my listeners have within the last few years seen the discovery of the Röntgen rays and the modern development of wireless telegraphy. On the chemical side we have witnessed the discovery of new elements in the atmosphere and the introduction of an entirely new branch of chemistry called physical chemistry. With such examples ready to our hands, who can say what further discoveries will not shortly be made, even in such well-worked fields as chemistry and physics?

The mention of physical chemistry brings me to what I may term the second head of my discourse, the second striking characteristic of modern chemical physiology: this is the increasing importance which physiologists recognise in a study of inorganic chemistry. The materials of which our bodies are composed are mainly organic compounds, among which the proteids stand out as pre-eminently important; but everyone knows there are many substances of the mineral or inorganic kingdom present in addition. I need hardly mention the importance of water, of the oxygen of the air, and of salts like sodium chloride and calcium phosphate.

The new branch of inorganic chemistry called physical chemistry has given us entirely new ideas of the nature of solutions, and the fact that electrolytes in solution are broken up into their constituent ions is one of fundamental importance. One of the many physiological aspects of this subject is seen in a study of the action of mineral salts in solution on living organisms and parts of organisms. Many years ago Dr. Ringer showed that contractile tissues (heart, cilia, &c.) continue to manifest their activity in certain saline solutions. Howell goes so far as to say, and probably correctly say, that the cause of the rhythmical action of the heart is the presence of these inorganic substances in the blood or lymph which usually bathes it. The subject has more recently been taken up by Loeb and his colleagues at Chicago: they confirm Ringer's original statements, but interpret them now as ionic action. Contractile tissues will not contract in pure solutions of non-electrolytes like sugar or albumin. But different contractile tissues differ in the nature of the ions which are their most favourable stimuli. An optimum salt solution is one in which stimulating ions, like those of sodium, are mixed with a certain small amount of those which like calcium restrain activity. Loeb considers that the ions act because they affect either the physical condition of the colloidal substances (proteid, &c.) in protoplasm or the rapidity of chemical processes.

Amœboid movement, ciliary movement, the contraction of muscle, cell division, and karyokinesis all fall into the same category as being mainly dependent on the stimulating action of ions.

Loeb has even gone so far as to consider that the process of fertilisation is mainly ionic action; he denies that the nuclein of the male cell is essential, but asserts that all it does is to act as the stimulus in the due adjustment of the proportions of the surrounding ions, and supports this view by numerous experiments on ova in which without the presence of spermatozoa he has produced larvæ by merely altering the saline constituents and so the osmotic pressure of the fluid that surrounds them. Whether such a sweeping and almost revolutionary notion will stand the test of further verification must be left to the future; so also must the equally important idea that nervous impulses are to be mainly explained on an electrolytic basis. But whether or not all the details of such work will stand the test of time, the experiments I have briefly alluded to are sufficient to show the importance of physical chemistry to the physiologist, and they also form a useful commentary on what I was saying just now about vitalism. Such eminently vital phenomena as movement and fertilisation are to be explained in whole or in part as due to the physical action of inorganic substances. Are not such suggestions indications of the undesirability of postulating the existence of any special mystic vital force?

I have spoken up to this point of physical chemistry as a branch of inorganic chemistry; there are already indications of its importance also in relation to organic chemistry. Many eminent chemists consider that the future advance of organic chemistry will be on the new physical lines. It is impossible to forecast where this will lead us; suffice it to say that not only physiology, but also pathology, pharmacology, and even therapeutics, will receive new accessions to knowledge the importance of which will be enormous.

I have now briefly sketched what appear to me to be the two main features of the chemical physiology of to-day, and the two lines, organic and inorganic, along which I believe it will progress in the future.

Let me now press upon you the importance in physiology, as in all experimental sciences, of the necessity first of bold experimentation, and secondly of bold theorising from experimental data. Without experiment all theorising is futile; the discovery of gravitation would never have seen the light if laborious years of work had not convinced Newton that it could be deduced from his observations. The Darwinian theory was similarly based upon data, and experiments which occupied the greater part of its author's lifetime to collect and perform. Pasteur in France and Virchow in Germany supply other instances of the same devotion to work which was followed by the promulgation of wide-sweeping generalisations.

And after all it is the general law which is the main object of research; isolated facts may be interesting and are often of value, but it is not until facts are correlated and the discoverers ascertain their interrelationships that anything of epoch-making importance is given to the world.

It is, however, frequently the case that a thinker with keen insight can see the general law even before the facts upon which it rests are fully worked out. Often such bold theorisers are right, but even if they ultimately turn out to be wrong, or only partly right, they have given to their fellows some general idea on which to work; if the general idea is incorrect, it is important to prove it to be so in order to discover what is right later on. No one has ever seen an atom or a molecule, yet who can doubt that the atomic theory is the sheet anchor of chemistry? Mendeleeff formulated his periodic law before many of the elements were discovered; yet the accuracy of this great generalisation has been such that it has actually led to the discovery of some of the missing elements.

I purpose to illustrate these general remarks by a brief allusion to two typical sets of researches carried out during recent years in the region of chemical physiology. I do not pretend that either of them has the same overwhelming importance as the great discoveries I have alluded to, but I am inclined to think that one of them comes very near to that standard. The investigations in question are those of Ehrlich and of Pawlow. The work of Ehrlich mainly illustrates the useful part played by bold theorising, the work of Pawlow that played by the introduction of new and bold methods of experiment.

I will take Pawlow first. This energetic and original Russian physiologist has by his new methods succeeded in throwing an entirely new light on the processes of digestion. Ingeniously devised surgical operations have enabled him to obtain the various digestive juices in a state of absolute purity and in large quantity. Their composition and their actions on the various foodstuffs have thus been ascertained in a manner never before accomplished; an apparently unfailing resourcefulness in devising and adapting experimental methods has enabled him and his fellow workers to discover the paths of the various nerve impulses by which secretion in the alimentary canal is regulated and controlled. The importance of the psychical element in the process of digestion has been experimentally verified. If I were asked to point out what I considered to be the most important outcome of all this painstaking work, I should begin my answer by a number of negatives, and would say, not the discovery of the secretory nerves of the stomach or pancreas; not the correct analysis of the gastric juice, nor the fact that the intestinal juice has most useful digestive functions; all of these are discoveries of which anyone might have been rightly proud; but after all they are more or less isolated facts. The main thing that Pawlow has shown is that digestion is not a succession of isolated acts, but each one is related to its predecessor and to that which follows it; the process of digestion is thus a continuous whole; for example, the acidity of the gastric juice provides for a delivery of pancreatic juice in proper quantity into the intestine; the intestinal juice acts upon the pancreatic, and so enables the latter to perform its powerful actions. I am afraid this example, as I have tersely stated it, presents the subject rather inadequately, but it will serve to show what I mean. Further, the composition of the various juices is admirably adjusted to the needs of the organism; when there is much proteid to be digested, the proteolytic activity of the juices secreted is correspondingly high, and the same is true for the other constituents of the food. It is such general conclusions as these, the correlation of isolated facts leading to the formulation of the law that the digestive process is continuous in the sense I have indicated and adapted to the needs of the work to be done, that constitute the great value of the work from the Russian laboratory. Work of this sort is sure to stimulate others to fill in the gaps and complete the picture, and already has borne fruit in this direction. It has, for instance, in Starling's hands led to the discovery of a chemical stimulus to pancreatic secretion. This is formed in the intestine as the result of the action of the gastric acid, and taken by the blood-stream to the pancreas. Whether this *secretin* as it is called may be one of a group of similar chemical stimuli which operate in other parts of the body has still to be found out.

The other series of researches to which I referred are those of Ehrlich and his colleagues and followers on the subject of immunity. This subject is one of such importance to every one of us that I am inclined to place the discovery on a level with those great discoveries of natural laws to which I alluded at the outset of this portion of my Address. I hesitate to do so yet because many of the details of the theory still await verification. But up to the present all is working in that direction, and Ehrlich's ideas illustrate the value of bold theorising in the hands of clear-sighted and far-seeing individuals.

But when I say that the doctrine is bold, I do not mean to infer that the experimental facts are scanty; they are just the reverse. But in the same way that a chemist has never seen an atom, and yet he believes atoms exist, so no one has yet ever seen a toxin or antitoxin in a state of purity, and yet we know they exist, and this knowledge promises to be of incalculable benefit to suffering humanity.

It may not be uninteresting to state briefly, for the benefit of those to whom the subject is new, the main facts and an outline of the theory which is based upon them.

We are all aware that one attack of many infective maladies protects us against another attack of the same disease. The person is said to be *immune* either partially or completely against that disease. Vaccination produces in a patient an attack of cowpox or vaccinia. This disease is related to smallpox, and some still hold that it is smallpox modified and rendered less malignant by passing through the body of a calf. At any rate an attack of vaccinia renders a person immune to smallpox, or variola, for a certain number of years. Vaccination is an instance of what is called *protective inoculation*, which is now practised with more or less success in reference to other diseases like plague and typhoid fever. The study of immunity has also rendered possible what may be called *curative inoculation*, or the injection of antitoxic material as a cure for diphtheria, tetanus, snake poisoning, &c.

The power the blood possesses of slaying bacteria was first discovered when the effort was made to grow various kinds of bacteria in it; it was looked upon as probable that blood would prove a suitable soil or medium for this purpose. It was found in some instances to have exactly the opposite effect. The chemical characters of the substances which kill the bacteria are not fully known; indeed, the same is true for most of the substances we have to speak of in this connection. Absence of knowledge on this particular point has not, however, prevented important discoveries from being made.

So far as is known at present, the substances in question are proteid in nature. The bactericidal powers of blood are destroyed by heating it for an hour to 56° C. Whether the substances are enzymes is a disputed point. So also is the question whether they are derived from the leucocytes; the balance of evidence appears to me to be in favour of this view in many cases at any rate, and phagocytosis becomes more intelligible if this view is accepted. The substances, whatever be their source or their chemical nature, are sometimes called alexins, but the more usual name now applied to them is that of *bacterio-lysins.*

Closely allied to the bactericidal power of blood, or blood-serum, is its globulicidal power. By this one means that the blood-serum of one animal has the power of dissolving the red blood-corpuscles of another species. If the serum of one animal is injected into the blood-stream of an animal of another species, the result is a destruction of its red corpuscles, which may be so excessive as to lead to the passing of the liberated hæmoglobin into the urine (hæmoglobinuria). The substance or substances in the serum that possess this property are called *hæmolysins*, and though there is some doubt whether bacterio-lysins and hæmolysins are absolutely identical, there is no doubt that they are closely related substances.

Another interesting chemical point in this connection is the fact that the bactericidal power of the blood is closely related to its alkalinity. Increase of alkalinity means increase of bactericidal power. Venous blood contains more diffusible alkali than arterial blood and is more bactericidal; dropsical effusions are more alkaline than normal lymph and kill bacteria more easily. In a condition like diabetes, when the blood is less alkaline than it should be, the susceptibility to infectious diseases is increased. Alkalinity is probably beneficial because it favours those oxidative processes in the cells of the body which are so essential for the maintenance of healthy life.

Normal blood possesses a certain amount of substanees which are inimical to the life of our bacterial foes. But suppose a person gets run down; everyone knows he is then liable to 'catch anything.' This coincides with a diminution in the bactericidal power of his blood. But even a perfectly healthy person has not an unlimited supply of bacterio-lysin, and if the bacteria are sufficiently numerous he will fall a victim to the disease they produce. Here, however, comes in the remarkable part of the defence. In the struggle he will produce more and more bacterio-lysin, and if he gets well it means that the bacteria are finally vanquished, and his blood remains rich in the particular bacterio-lysin he has produced, and so will render him immune to further attacks from that particular species of bacterium. Every bacterium seems to cause the development of a specific bacterio-lysin.

Immunity can more conveniently be produced gradually in animals, and this applies, not only to the bacteria, but also to the toxins they form. If, for instance, the bacilli which produce diphtheria are grown in a suitable medium, they produce the diphtheria poison, or toxin, much in the same way that yeast-cells will produce alcohol when grown in a solution of sugar. Diphtheria toxin is associated with a proteose, as is also the case with the poison of snake venom. If a certain small dose called a 'lethal dose' is injected into a guinea-pig the result is death. But if the guinea-pig receives a smaller dose it will recover; a few days after it will stand a rather larger dose; and this may be continued until after many successive gradually increasing doses it will finally stand an amount equal to many lethal doses without any ill effects. The gradual introduction of the toxin has called forth the production of an antitoxin. If this is done in the horse instead of the guinea-pig the production of antitoxin is still more marked, and the serum obtained from the blood of an immunised horse may be used for injecting into human beings suffering from diphtheria, and rapidly cures the disease. The two actions of the blood, antitoxic and antibacterial, are frequently associated, but may be entirely distinct.

The antitoxin is also a proteid probably of the nature of a globulin; at any rate it is a proteid of larger molecular weight than a proteose. This suggests a practical point. In the case of snake-bite the poison gets into the blood rapidly owing to the comparative ease with which it diffuses, and so it is quickly carried all over the body. In treatment with the antitoxin or antivenin, speed is everything if life is to be saved; injection of this material under the skin is not much good, for the diffusion into the blood is too slow. It should be injected straight away into a blood-vessel.

There is no doubt that in these cases the antitoxin neutralises the toxin much in the same way that an acid neutralises an alkali. If the toxin and antitoxin are mixed in a test-tube, and time allowed for the interaction to occur, the result is an innocuous mixture. The toxin, however, is merely neutralised, not destroyed; for if the mixture in the test-tube is heated to 68° C. the antitoxin is coagulated and destroyed and the toxin remains as poisonous as ever.

Immunity is distinguished into *active* and *passive*. Active immunity is produced by the development of protective substances in the body; passive immunity by the injection of a protective serum. Of the two the former is the more permanent.

Ricin, the poisonous proteid of castor-oil seeds, and *abrin*, that of the Jequirity bean, also produce when gradually given to animals an immunity, due to the production of antiricin and antiabrin respectively.

Ehrlich's hypothesis to explain such facts is usually spoken of as the *side-chain theory* of immunity. He considers that the toxins are capable of uniting with the protoplasm of living cells by possessing groups of atoms like those by which nutritive proteids are united to cells during normal assimilation. He terms these *haptophor* groups, and the groups to which these are attached in the cells he terms *receptor* groups. The introduction of a toxin stimulates an excessive production of receptors, which are finally thrown out into the circulation, and the free circulating receptors constitute the antitoxin. The comparison of the process to assimilation is justified by the fact that non-toxic substances like milk introduced gradually by successive doses into the blood-stream cause the formation of anti-substances capable of coagulating them.

Up to this point I have spoken only of the blood, but month by month workers are bringing forward evidence to show that other cells of the body may by similar measures be rendered capable of producing a corresponding protective mechanism.

One further development of the theory I must mention. At least two different substances are necessary to render a serum bactericidal or globulicidal. The bacterio-lysin or hæmolysin consists of these two substances. One of these is called the *immune body*, the other the *complement*. We may illustrate the use of these terms by an example. The repeated injection of the blood of one animal (*e.g.*, the goat) into the blood of another animal (*e.g.*, a sheep) after a time renders the latter animal immune to further injections, and at the same time causes the production of a serum which dissolves readily the red blood-corpuscles of the first animal. The sheep's serum is thus hæmolytic towards goat's blood-corpuscles. This power is destroyed by heating to 56° C. for half an hour, but returns when fresh goat's serum is added. The specific immunising substance formed in the sheep is called the immune body; the ferment-like substance destroyed by heat is the complement. The latter is not specific, since it is furnished by the blood of non-immunised animals, but it is nevertheless essential for hæmolysis. Ehrlich believes that the immune body has two side groups—one which connects with the receptor of the red corpuscles and one which unites with the haptophor group of the complement, and thus renders possible the ferment-like action of the complement on the red corpuscles. Various antibacterial serums which have not been the success in treating disease they were expected to be are probably too poor in complement, though they may contain plenty of the immune body.

Quite distinct from the bactericidal, globulicidal, and antitoxic properties of blood is its agglutinating action. This is another result of infection with many kinds of bacteria or their toxins. The blood acquires the property of rendering immobile and clumping together the specific bacteria used in the infection. The test applied to the blood in cases of typhoid fever, and generally called Widal's reaction, depends on this fact.

The substances that produce this effect are called *agglutinins*. They also are probably proteid-like in nature, but are more resistent to heat than the lysins. Prolonged heating to over 60° C. is necessary to destroy their activity.

Lastly, we come to a question which more directly appeals to the physiologist than the preceding, because experiments in relation to immunity have furnished us with what has hitherto been lacking, a means of distinguishing human blood from the blood of other animals.

The discovery was made by Tchistovitch (1899), and his original experiment was as follows:—Rabbits, dogs, goats, and guinea-pigs were inoculated with eel-serum, which is toxic: he thereby obtained from these animals an antitoxic serum. But the serum was not only antitoxic, but produced a precipitate when added to eel-serum, but not when added to the serum of any other animal. In other words, not only has a specific antitoxin been produced, but also a specific *precipitin*. Numerous observers have since found that this is a general rule throughout the animal kingdom, including man. If, for instance, a rabbit is treated with human blood, the serum ultimately obtained from the rabbit contains a specific precipitin for human blood; that is to say, a precipitate is formed on adding such a rabbit's serum to human blood, but not when added to the blood of any other animal.[1] The great value of the test is its delicacy: it will detect the specific blood when it is greatly diluted, after it has been dried for weeks, or even when it is mixed with the blood of other animals.

I have entered into this subject at some length because it so admirably illustrates the kind of research which is now in progress; it is also of interest to others than mere physiologists. I have not by any means exhausted the subject, but for fear I may exhaust my audience let me hasten to a conclusion. I began by eulogising the progress of the branch of science on which I have elected to speak to you. Let me conclude with a word of warning on the danger of over-specialisation. The ultra-specialist is apt to become narrow, to confine himself so closely to his own groove that he forgets to notice what is occurring in the parallel and intercrossing grooves of others. But those who devote themselves to the chemical side of physiology run but little danger of this evil. The subject cannot be studied apart from other branches of physiology, so closely are both branches and roots intertwined. As an illustration of this may I be permitted to speak of some of my own work? During the past few years the energies of my laboratory have been devoted to investigations on the chemical side of nervous activity, and I have had the advantage of co-operating to this end with a number of investigators, of whom I may particularly mention Dr. Mott and Dr. T. G. Brodie. But we soon found that any narrow investigation of the chemical properties of nervous matter and the changes this undergoes during life and after death was impossible. Our work extended in a pathological direction so as to investigate the matter in the brains of those suffering from nervous disease; it extended in a histological direction so as to determine the chemical meaning of various staining reactions presented by normal and abnormal structures in the brain and spinal cord; it extended in an experimental direction in the elucidation of the phenomena of fatigue, and to ascertain whether there was any difference in medullated and non-medullated nerve fibres in this respect; it extended into what one may call a pharmacological direction in the investigation of the action of the poisonous products of the breakdown of nervous tissues. I think I have said enough to show you how intimate are the connections of the chemical with the other aspects of physiology, and although I have given you but one instance, that which is freshest to my mind, the same could be said for almost any other well-planned piece of research work of a bio-chemical nature.

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[1] There may be a slight reaction with the blood of allied animals; for instance, with monkey's blood in the case of man.

We have now before us the real work of the Section, the reading, hearing, and seeing the researches which will be brought forward by members of the Association, and I must, in thanking you for your attention, apologise for the length of time I have kept you from these more important matters.

The following Papers were read:—

1. *The Hydrolysis of Glycogen.*
By W. A. OSBORNE, *D.Sc., and* S. ZOBEL.

2. *On the Innervation and Movements of the Stomach.*
By W. PAGE MAY, *M.D.*

3. *The Functions of the Rods and Cones of the Retina.*
By F. W. EDRIDGE-GREEN, *M.D.*

FRIDAY, SEPTEMBER 12.

The following Papers were read:—

1. *On the Diuretic Action of Pituitary Extracts.*
By Professor E. A. SCHÄFER, *F.R.S.*

2. *On the Relative Effects of Section of the Pyramidal Tracts and Anterior Columns in the Monkey.* *By* Professor E. A. SCHÄFER, *F.R.S.*

The experiments show that section either of the pyramidal tracts in the medulla oblongata or of the anterior columns of the spinal cord is followed by paralysis of voluntary motion in the parts of the body below the section. Since the descending fibres of the anterior columns are in the main derived from the cells of Deiters' nucleus in the medulla oblongata, and Deiters' nucleus is, on the other hand, related to the part of the auditory nerve which is connected to the semicircular canals, and since further destruction of the semicircular canals has been proved to be followed by loss of tone of the muscles of the body, it seems probable that the effect of section of the anterior columns in causing paralysis is also due to loss of tone, in the same way that section of the posterior roots of the nerves supplying a limb may cause voluntary paralysis of the muscles of that limb by producing loss of tone in the motor nerve cells.

3. *A Case of Paralysis of Convergence.*
By CYRIL SHAW, *M.D.*

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4. *Determination of the Least Perceptible Tone-difference among the People of the Torres Straits and of Scotland.* *By* C. S. MYERS, *M.A., M.D.*

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5. *Some new Features in the Intimate Structure of the Human Cerebral Cortex.* *By* JOHN TURNER, *M.B.*

I. The new features referred to are:—

(1) A beaded network enveloping the pyramidal cells of the cortex and their dendrites, which although it has been seen in animals by intra-vitam staining has not before been demonstrated in human beings.

(2) An intercellular plexus of nerve-fibrils which has, I believe, not before been actually demonstrated. The method employed consists in staining pieces of brain tissue in a mixture of methylene blue and peroxide of hydrogen direct on their removal from the body, *i.e.*, without previous hardening or fixing. The tissue is *subsequently* fixed in solution of molybdate of ammonia, dehydrated, and cut in paraffin.

II. The points dealt with are:—

(1) The pericellular network.
(2) The differentiation of the cells into pale and dark varieties.
(3) The origin of the network from the dendrites of the dark cells.
(4) The junction of collaterals also with the network.
(5) The intercellular plexus of fine fibrils.

1. *The Network.*—It is shown to envelope the body and the protoplasmic process of the pale or pyramidal system of cells, and it is not a closed structure proceeding from the arborisation of a single fibre, but shows numerous delicate fibrils passing to it on all sides; and as these can be shown to proceed from different cells, it follows that such cells must be in organic continuity with each other. The beads on the network appear to form the nodal points for the meshes.

It is suggested that the appearance of 'thorns' on the protoplasmic processes of the pyramidal cells shown by Golgi's method is really an artefact, caused by a deposition of the silver about the little tags which pass off nearly at right angles from the heads of the network, both from the cell-body and its dendrites.

2. *The Differentiation of the Cells into Pale and Dark Varieties.*—The pyramidal cells are very lightly stained, and as a rule their processes cannot be followed far; other cells and their processes are very darkly stained, almost black in many cases.

This division of cells is also maintained in the cerebellar cortex, where the antler cells are pale and the basket and small cortical cells are dark.

There are other distinctions which mark off the two varieties, *e.g.*, the dark cells, unlike the pyramidal, show no definite orientation: they are of various shapes and sizes, but are generally small and most often oval or polygonal in shape; they occur scattered about throughout the cortex, at least from the second to the fourth layers inclusive, but are most numerous, roughly speaking, about the junction of the outer and middle thirds of the cortex, and more numerous in the frontal and occipital regions than in the so-called motor (ascending frontal); some of them have ascending axis cylinders (Martmotti's cells), others have descending.

3. The dendrites of the dark cells branch into delicate-*beaded* fibrils, and it can be demonstrated that these are directly united to and in fact form the pericellular network.

These delicate-beaded branches and also fine-headed branches, which come off in great numbers from the coarser branches (giving them a shaggy appearance), form the intercellular plexus.

4. Collaterals given off from the axis cylinders, probably of pyramidal cells, can also be demonstrated to join to the network.

5. *The Intercellular Plexus.*—This consists of a dense mass of extremely fine-beaded fibrils intersecting each other in all directions, but probably not joining at the intersections.

It can be demonstrated to proceed from the dendrites of the dark cells and to pass to the pericellular network. In fact the network is merely an extension of the plexus, but apparently except at this network the individual fibres which meet together on all sides to form it do not join but merely overlap.

This plexus differs essentially from those *conceived* by (but never demonstrated) Gerlach, Golgi, or Nevil, inasmuch as it is not a derivative from the protoplasmic processes of the pyramidal cells and is only indirectly concerned with these cells by means of the junctions of the collaterals already referred to, and which probably are given off from the axis cylinders of the pyramidal cells.

Conclusion.

The above observations show:—

(1) That there is a system of cortical nerve-cells which, by means of their protoplasmic processes, are in organic continuity, through the medium of a pericellular network which envelopes the pyramidal cells.

(2) That collaterals, arising in all probability from the axes cylinders of the pyramidal cells, also join on to this network.

(3) And that therefore practically all the nerve-cells of the cortex are in organic continuity.

(4) It is suggested that the difference in staining, shape, &c., of the two varieties of cells implies a corresponding difference in function, and as we have good ground for associating the pyramidal cells with motor functions, that the dark cells are associated with sensory functions—in other words that they are bearers and distributors of afferent stimuli, and that by this method, therefore, we have a means of showing where ingoing currents end and where outgoing currents are initiated.

(5) But if the dark cells are bearers of afferent stimuli this further implies that nerve-currents do not invariably flow in one direction—viz., from the dendrites to the cell and from the cell out by way of the axis cylinder, a view very generally held—but that in some cases it flows into the cell by the axis cylinder and out by the dendrites.

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6. *The Nervous System of the Camel.*

By W. PAGE MAY, *M.D.*

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7. *Regeneration of Nerves.*

By W. D. HALLIBURTON, *M.D., F.R.S., and* F. W. MOTT, *M.D., F.R.S.*

Some experiments which we performed on the nerves of cats, and which had for their object the study of the process of degeneration in nerve-fibres, have led us during the past year to take up the related question of regeneration.

From the microscopic study of the distal portions of divided nerve-trunks we arrived at the conclusion that the activity of the neurilemmal cells has some relation to the development of the new nerve-fibres. These cells elongate and become connected end to end, and thus lead to the formation of what look like embryonic nerve-fibres.

Those who have worked at the regeneration of nerve-fibres may be divided into two schools: those who believe that the new fibres sprout out from the central stump of the divided nerve, and those who consider that the new fibres have a peripheral origin. Those who hold the latter view rely almost exclusively on histological evidence; a strand that looks like a nerve-fibre to the microscope cannot be a nerve-fibre unless it is shown experimentally by stimulation to be both excitable and capable of conducting nerve-impulses. Among recent writers, Howell and Huber, who have used both histological and experimental methods, have arrived at the conclusion that although the peripheral structures are active in preparing the scaffolding, the axis cylinder, the essential portion of a nerve-fibre, has an exclusively central origin. Our experiments, which have been made on monkeys, are at present incomplete, and this communication must therefore be regarded as only of a preliminary nature. But so far as we have gone at present our conclusions tend to confirm those of Howell and Huber.

One experiment which we have done was suggested to us by Professor Gotch, and the result was very striking. A large nerve was divided and the ends sutured together. After a sufficient length of time had passed, restoration of function led us to suppose that regeneration had occurred. The nerve was exposed; the union of the two ends was found to have been accomplished, and the nerve was excitable below and above the junction. A piece of the nerve was then excised a little distance below the junction, and on histological examination of this, new nerve-fibres were discovered in it. After this second operation the wound was closed up and the animal allowed to live for ten days longer. It was then killed, and the nerve both above and below the second cut examined; no degeneration was found in the nerve-fibres above the lesion, but there was distinct evidence of the degenerative process in the fibres of the peripheral end, which was quite inexcitable. This showed us that the degeneration process which followed the direction of growth had occurred in a peripheral direction only, and is a strong piece of evidence that growth had not started from the periphery centralwards, or at any rate that the direction of nutritive control is from the centre towards the periphery.

Other experiments which we have done illustrate the important influence of stimulus in the regenerative process. A monkey's arm was rendered immobile by the division of a number of the upper posterior roots. The anterior cornual cells from which the motor-fibres originate are thus not subjected to stimuli from the periphery, and the arm is as much paralysed as if the anterior roots had been cut. Warrington has already shown that under these circumstances the anterior horn cells undergo the chromatolytic change which is associated with inactivity. A large nerve in the arm (ulnar or median) was then divided, and the same nerve was divided on the non-paralysed side as a control experiment. The animal was finally killed; the interval between the operation and death varied in different experiments. We have already found that if sufficient time had elapsed, union of the divided ends occurred on both sides of the body, but on the side corresponding to that on which the posterior roots had been divided the nerve was either inexcitable or required very strong Faradic stimulation to make it respond; histologically the nerve showed a much looser texture, and new nerve-fibres though present were less numerous than on the control side, where the microscope revealed that regeneration had occurred in the usual way, and the new nerve-fibres responded to stimuli readily. This tends to show the importance of stimulus to the reparative process.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Papers and Reports were read :—

1. *The Estimation of Urea in Physiological Fluids.*
By J. BARCROFT, *M.A.*, *B.Sc.*

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2. *Demonstration of Edinger's Apparatus for Higher Magnifications and Stronger Light.* *By* Professor SYMINGTON, *M.D.*, *and* CECIL SHAW, *M.D.*

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3. *The Pigments of Ox Bile.* *By* W. A. OSBORNE, *D.Sc.*

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4. *The Indefatigability of Medullated Nerve.*
By Professor F. GOTCH, *F.R.S.*

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5. *Report on the Work of the Mammalian Heart.*—See Reports, 470.

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6. *Report on the Micro-chemistry of Cells.*—See Reports, p. 470.

SECTION K.—BOTANY.

PRESIDENT OF THE SECTION—Professor J. REYNOLDS GREEN, M.A., Sc.D., F.R.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

THE visits of the British Association to a particular city recur with a certain irregular frequency and bring with them a temptation to the President of a Section to dwell in his opening Address on the progress made in the science associated with that Section during the interval between such consecutive visits. This course possesses a certain fascination of its own, for it enables us to realise how far the patient investigations of years have ultimately led to definite advances in knowledge and to appreciate the difficulties that have involved disappointments, and that still have to be surmounted. We like to look back upon the struggles, to record the triumphs, to deplore the failures, and to brace ourselves for new efforts. The opportunity afforded hereby for criticism of methods, for reconsideration of what have been held to be fundamental principles, for the laying down of new lines of work based upon longer experience, shows us how desirable such a periodical retrospect may be.

Standing as we do almost at the threshold of a new century, it seems particularly advisable that we shall occupy our thoughts with some such considerations to-day. I do not wish, however, so much to dwell upon the past and to lead my hearers to rest in any way satisfied with the achievements of the last century, phenomenal as they have been, as to direct attention to the future and to place before you some of those problems which at the opening of the twentieth century we find awaiting investigation, if not solution.

I can only attempt to deal with a small portion of the botanical field. These are the days of specialisation, and when anyone is said to be a botanist, the question which arises at once is, Which particular section of botany is he associated with? The same principle of subdivision which cut up the old subject of Natural History into Zoology, Botany, and Geology has now gone further as knowledge has increased, and three or perhaps four departments of botany must be recognised, each demanding as much study as the whole subject seemed to only fifty years ago. I shall therefore confine my remarks to-day to the field of vegetable physiology.

I should like at the outset to recommend this section of botanical work to those of the younger school of botanists who are contemplating original research. To my mind the possibilities of the living organism as such present a fascination which is not afforded by the dry bones of morphology or histology; valuable as researches into the latter are, they seem to me to derive their importance very largely from the past, from the possibility of indicating or ascertaining the line of descent of living forms and the relation of the latter to their remote ancestors. The interest thus excited seems to me to be rather of an academic character when compared with the actual problems of present-day life, its struggles, triumphs, and defeats in the conflict for existence waged to-day by every living organism. The importance of the study of physiology as bearing upon the problems of the morphologists has, I need hardly say, been fully recognised by the workers in that field. I may quote here a sentence or two from the Address of one of my distinguished predecessors, who said at Liverpool, 'There is a close relation between these two branches of biology, at any rate to those who maintain the Darwinian position, for from that point of view we see that all the characters which the morphologist has to compare are, or have been, adaptive. Hence it is impossible for the morphologist to ignore the functions of those organs of which he is studying the homologies. To those who accept the origin of species by variation and natural selection there are no such things as morphological characters pure and simple. There are not two distinct categories of characters—a morphological and a physiological category—for all characters alike are physiological.'

But apart from the considerations of the claims of vegetable physiology based upon its own intrinsic scientific value and the interest which its problems possess for the worker himself, and upon the place accorded to it as its relationship to morphology, it must, I think, be recognised as being of fundamental economic importance, especially in these times of agricultural depression. For many years now it has been recognised that agriculture is based upon science; that it involves indeed properly the application of scientific principles to the cultivation of the soil. But when we look back upon what has passed for agricultural science since the alliance between the two has been admitted, we cannot but recognise how lamentably deficient in breadth it has been. The chemical composition of the soil and subsoil has been investigated with some thoroughness in many districts of the country. The effect of its various constituents on the weight and quality of the crops cultivated in it has been exhaustively inquired into, and a considerable amount of information as to what minerals are advantageously applied to the soil in which particular plants are to be sown has been acquired. A kind of empirical knowledge is thus in our possession, in some respects a very detailed one, quantitative as well as qualitative records being available to the inquirer. But elaborate as have been the researches in these directions, and costly and troublesome as the investigations have been, they have been hardly, if at all, more than empirical. Till quite recently the physiological idiosyncrasies of the plants round which all these inquiries centred were almost entirely ignored. No serious attempt was made to ascertain the way in which a plant benefited by or suffered from the presence of a particular constituent of the soil. What influence, for instance, has potassium or any of its compounds upon the general metabolism of the plant? Does it affect all its normal nutritive processes, or does it specially associate itself with some particular one? If so which one, and how does the plant respond to its presence or absence by modifying its behaviour? So with phosphorus again; hardly any investigation can be made into the nutritive processes of a plant without this element becoming more or less prominent. In some cases the empirical results already referred to show an enormous influence on the crop exerted by soluble phosphates in the soil or the manure applied to it. But what can yet be said as to the rôle played by phosphorus or by phosphates in the metabolic processes in the plant? Further, how do different plants show different peculiarities in their reactions to these various constituents of the soil? For the advance of agriculture the study of the plant itself must now be added to the study of the soil. The fact that it is a living organism possessing a certain variable and delicate constitution, responding in particular ways to differences of environment, capable of adapting itself to a certain extent to its conditions of life, dealing in particular ways with different nutritive substances, must not only be recognised, but must be the basis for the researches of the future, which will thus supplement and enlarge the conclusions derived from those of the past, in some respects correcting them, in others establishing them on a firmer basis.

In pressing upon the younger school of botanists the importance of this line of research, I do not wish to minimise the difficulties that accompany it. Difficulties of method assume considerable magnitude, for we have here no question of section cutting and microscopic examination. Vegetable physiology is allied very closely to other sciences, and research into its mysteries involves more than a preliminary acquaintance with them. Especially must one point out the importance, indeed the necessity, of acquaintance with a certain range of organic chemistry and with chemical methods of work. In certain directions, too, physics are as much involved as chemistry in others. The bearing of these sciences in particular directions will be referred to later.

I fear another obstacle stands at the threshold of research which looks sufficiently formidable. The so-called fundamental facts of vegetable physiology have been laid down with sufficient dogmatism in text-books by many writers whose names carry with them such weight that it appears almost heresy to question their statements. We have been content to accept many things on the authority of the great workers of the past, with the result that the advance of knowledge has been hindered by such acceptance of what were deemed facts, but were really inaccuracies. We may refer, for instance, to the statement made by Boussingault, and accepted by most botanists ever since his time, that the absorption of carbon dioxide from the air takes place by means of solution in the cuticle of the epidermal cells of plants and thence passes by diffusion to the seats of photosynthesis. Only comparatively recently has this been shown to be erroneous. If, however, it is once recognised that authority is fallible this apparent obstacle becomes the opposite. The more evident questions have not yet been solved, leaving only the more difficult ones for the present-day worker.

Recognising the importance of work in this field, and realising that with the advent of a new century new departures must be taken, I have thought I might venture to direct the thoughts of my hearers, many of whom I may call my colleagues, to the present position of certain problems which have long been the subjects of speculation and which offer the prospect, if not of complete solution, at any rate of considerable advance if investigated by modern methods.

I turn first to a few questions connected with the nutritive problems of plants in general.

There are several theories abroad as to the progress of events during photosynthesis, none of which can be regarded as entirely satisfactory. For many reasons it seems desirable that this question shall be thoroughly investigated in the light of the present condition of both chemical and physical science. I may perhaps venture to recall to you the principal hypotheses of carbohydrate formation which have been advanced, so that its present position may be properly appreciated.

The view that has met with the widest acceptance is that of Baeyer. On his hypothesis the carbon dioxide absorbed is decomposed under normal conditions to yield carbon monoxide and oxygen; a corresponding and coincident decomposition of water leads to the production of free hydrogen and oxygen. The oxygen from both sources is exhaled, while the carbon monoxide and hydrogen combine to form formaldehyde. The formaldehyde gives rise by a process of polymerisation to some form of sugar.

A modification of this hypothesis has been advanced, which suggests that the preliminary decomposition of the carbon dioxide and the water may not take place, but that by a rather less violent reaction between them the formaldehyde may be formed and the oxygen liberated.

Erlenmeyer has suggested a somewhat different course of reaction, yielding substantially the same results. He thinks it possible that the first interaction of carbon dioxide and water leads to the formation of formic acid and hydrogen peroxide, and that these subsequently interact with each other, yielding formaldehyde and water and giving off oxygen.

Many years after the views of Baeyer appeared, a hypothesis of a different nature was proposed by Crato. He suggests that the carbon dioxide after absorption becomes ortho-carbonic acid, and that this remains in solution in the cell sap. This acid has the structure of a closed benzene ring in which six molecules are linked together. This becomes decomposed, liberating six molecules of water and six molecules of oxygen, and forming a hexavalent phenol which subsequently undergoes a molecular rearrangement and becomes glucose.

Yet another suggestion was made by Bach in 1893. He points out that when sulphurous acid is exposed to light it becomes transformed to sulphuric acid, sulphur and water being split off, and he argues that a process analogous with this may take place in a leaf. The carbon dioxide uniting with water would form carbonic acid, and this might then split up in the same way as the sulphurous acid. The carbon and the water thus split off are on this hypothesis not set free separately, but in combination as formaldehyde. The higher carbon acid, to which Bach ascribes the formula H_2CO_4, splits up into carbon dioxide and hydrogen peroxide, and the latter is decomposed into water and free oxygen.

Lieben has still more recently put forward the view that formic acid and not formaldehyde is formed by the first decompositions. He has found that leaves of grasses and various trees yield formic acid among other products when mixed with their own weight of water containing a trace of sulphuric acid, and distilled with steam. Moreover, when carbon dioxide is acted upon by nascent hydrogen the only product is formic acid.

These speculations afford many points which might be well made the starting places of research. The views of Baeyer have met with most acceptance, though but little success has attended the few efforts that have been made to establish them by experiment.

They involve several definite stages of action, of which the most important seem the production of carbon monoxide and hydrogen, the formation of formaldehyde, and the construction of a sugar. The last two questions arise also in connection with the hypothesis of Bach.

If we examine the work that has been published bearing on the probability of the formation of carbon monoxide in the plant we find little that is satisfactory. The statements that have been made are opposed to the idea that carbon monoxide is of value in nutrition; it is said that when supplied to a plant instead of carbon dioxide it does not lead to the formation of carbohydrates. It is further advanced that this gas is of a very deleterious nature, and if formed would result in the speedy death of the protoplasm of the cell in which it originates. This idea is, of course, specious; but it does not appear to be well founded. The deadly character of carbon monoxide when inhaled by a human being depends upon a peculiar interference which it causes with the oxygen-carrying power of the red blood corpuscles. The pigment hæmoglobin to which these little bodies owe their usefulness forms a loose chemical combination with oxygen, the compound being formed in the blood vessels of the lungs and being decomposed with the liberation of the oxygen in those of the tissues of the body. It is evident, therefore, that the value of the corpuscles as oxygen-carriers depends upon their hæmoglobin. When this pigment is exposed to carbon monoxide it combines with it in the same way as it does with oxygen, forming, however, a more stable compound. The affinity for this gas which the pigment manifests is very considerable. Hence the poisonous nature of carbon monoxide. It is easily seen that the latter is a poison because it throws out of gear and temporarily paralyses a most essential part of the mechanism of respiration, effectually preventing oxygen from reaching the tissues of the body. There is no evidence here that it exerts even a deleterious influence upon the living substance itself. The only poisonous effect it would be able to exert on the plant would necessarily be of the latter character, for there is no oxygen-carrying mechanism that could be interfered with. We cannot lay any stress, therefore, on the objection to Baeyer's view, based upon the action of carbon monoxide upon the human organism.

Another possibility may, however, be mentioned. As we shall see later, there are certain resemblances between hæmoglobin and chlorophyll, the vegetable pigment concerned in photosynthesis. May not carbon monoxide enter into some relationship with the latter, and thereby indirectly hinder its activity? Of that, however, there is no reliable evidence, the facts known to us rather pointing in the opposite direction.

The idea of the poisonous nature of this gas may easily be subjected to experimental examination. It would appear easy to expose a plant to an artificial atmosphere made up to different partial pressures of carbon monoxide, to expose it in such atmospheres to various conditions of warmth and illumination and to note the effect produced. It would seem possible to examine a great variety of plants in that way, to try both aërial and aquatic forms, and indeed to test the matter exhaustively. It must be borne in mind, however, that the solubility of carbon monoxide in water is extremely small, and that there may be a great difficulty in getting it brought within the scope of the influence of the living substance on that account. It must necessarily be in solution in the cell sap before it can affect the activity of the chloroplast. Even the relations of solubility are not, however, outside the range of experiment, and it may be that the slightly acid cell sap has not the same peculiarities as water as a solvent for the gas.

It is important again to take into account in such work the factor of sunlight, on which the power of photosynthesis depends. Should carbon monoxide prove capable of serving as a basis for the formation of carbohydrates, the question would arise, Is the activity of the chlorophyll in sunlight confined to the preliminary formation of carbon monoxide from the dioxide, or is the energy derived from the light brought to bear upon the subsequent constructive processes? We have little or no accurate information as to the way in which the energy is utilised after absorption by the chlorophyll.

This opens up a very important but very difficult line of work, which brings home to us the intimate dependence of vegetable physiology upon physics. The absorption of energy from without, in the form of the radiant energy of the solar rays, is certainly a fact, and to a certain extent we can picture to ourselves the way in which it is secured. The spectrum of chlorophyll shows us a number of absorption bands whose position corresponds with the position in the spectrum of the places where oxygen is liberated in photosynthesis. But the transformation and applications of energy in the body of the vegetable organism need much closer examination. The intimate relationship between the different manifestations or forms of energy and the ways in which they can be transformed into one another have been very minutely scrutinised in recent times. What then should hinder us from learning something much more definite than we at present know about these transformations in the rôle of vegetable life? The electrical phenomena connected with the movements of the leaves of the Venus's fly-trap (*Dionæa muscipula*) have been examined with considerable completeness by Burdon Sanderson, and we have learned that the vegetable and animal organisms show considerable similarities in this respect. Recently again Bose has made important contributions to the subject of the electrical responses to stimulation that can be observed under particular conditions. A promising beginning has thus been made, but only a beginning. The electrical condition of the normal plant under different conditions of rest and activity has still to be investigated. If we return to the subject of photosynthesis and the work done by the chloroplast, may we not hope to discover something about the transformation and utilisation of the radiant energy associated somehow with this structure? Considering the relations between the manifestations of energy which we appreciate respectively as light and electricity, it does not seem wildly improbable to imagine that the energy absorbed as the former may lead to a possible electrolysis of carbonic acid under the influence of the chloroplast, with the formation of carbon monoxide and oxygen. Pfeffer has suggested that perhaps the decomposition of the gas is not due to the light rays at all, and that they may exercise only a stimulating influence upon the chloroplast, the energy concerned being derived from heat rays directly absorbed, or heat vibrations derived from the more rapidly vibrating light rays. In this case is the decomposition brought about directly by the heat vibrations, or have we a transmutation into some other form of energy? The whole subject seems at all events a promising subject for inquiry.

Another problem connected with the action of chlorophyll is associated with the absorption of radiant energy by the different regions of the spectrum. Bands of considerable intensity are noticeable in the blue and violet, though the deepest absorption takes place in the red. Yet Engelmann's classic bacterium method shows us that very little evolution of oxygen takes place in the position of these bands in the blue and violet. The fact that absorption of radiant energy and photosynthetic activity show no quantitative relationship is of course not new, but the reason remains still to be discovered. Van Tieghem has suggested an explanation which recalls to us the hypothesis advanced by Pfeffer, just alluded to. This explanation is that there are two factors concerned in the action of chlorophyll, the elective absorption of light, shown by the occurrence of the absorption bands in the spectrum, and the calorific energy of the absorbed radiations. The failure of the rays of the blue and violet to effect photosynthesis, in spite of their absorption, would on this view be attributable to their possessing but little calorific energy. The latter is associated much more strongly with the deep band in the red, which is the seat of the maximum evolution of oxygen when the spectrum is thrown upon a collection of active chloroplasts. The heating rays alone are ineffectual, as shown by the fact that there is no liberation of oxygen in the region of the infra-red, due no doubt to the fact that chlorophyll does not absorb these rays.

Timiriazeff, in his classical researches on the liberation of oxygen by the leaves of the bamboo when exposed in tubes of small calibre to a large spectrum, found that the amount of carbon dioxide decomposed by leaves is proportional to the distribution of effective calorific energy in the spectrum.

Van Tieghem's hypothesis that this is a matter of calorific energy may prove to be erroneous, and yet his views may rest on some sound basis. It may be a matter in which electrical rather than calorific energy may be concerned.

Returning now to the chemical steps demanded by Baeyer's hypothesis there are certain considerations which may be urged in favour of the view that carbon monoxide really occurs in photosynthesis. It has been ascertained by Norman Collie that when a mixture of gases containing a large proportion of carbon dioxide is exposed at low pressures in a vacuum tube to the action of an electric discharge from an induction coil there is a very large formation of the monoxide, together with oxygen, in some cases as much as 70 per cent. of the gas, undergoing decomposition.

Appealing to the experience of various observers there seems on the whole to be a balance of evidence in favour of the power of plants to live and prosper in an atmosphere containing a very considerable percentage of carbon monoxide.

The question of the possibility of the latter replacing the dioxide, as the theory appears to require, is complicated very seriously by the differences of solubility between them. Carbon dioxide dissolves very readily in water and in cell sap; carbon monoxide is almost insoluble in either. As the amount of a gas taken up by a solvent depends not only on its solubility, but upon its partial pressure, it is very evident that we cannot compare the two gases by admitting the same quantity of both to plants under simultaneous comparison. It is only necessary to supply the dioxide in the proportion of four parts in 10,000; but the almost insoluble nature of the monoxide makes it inevitable that from two to five per cent. shall be experimented with. The same question of solubility makes it almost out of the question to experiment with an aquatic plant.

It would be of considerable interest from this point of view also to inquire whether if carbon monoxide is liberated at the outset of the photosynthetic processes its combination with other groupings can take place apart from the action of chlorophyll. If so the fungi should be capable of carbohydrate construction if supplied under proper conditions with the monoxide and with hydrogen. The proper conditions, however, might be extremely difficult to establish.

The next stage in the constructive process affords still ample room for investigation. The presence of formaldehyde is not the hypothesis of Baeyer alone, but is demanded according to Bach's views, though the stages of its hypothetical construction are not the same. We have therefore to ask whether formaldehyde can be detected in plants, and if so whether the conditions under which it may exist admit of its being considered an up-grade product in photosynthesis. Objections to the theory of its formation may be advanced based upon its undoubtedly poisonous nature. Of all the antiseptics now available to the bacteriologists it is perhaps the most potent, even traces being fatal to the form of vegetable protoplasm which is found in bacteria. We may argue that it must be equally deleterious in the cell containing chlorophyll and to the chloroplast itself, as we have no reason to suppose that any difference in vitality exists between the protoplasm of different plants. At first sight this appears an almost insuperable difficulty in the way of the theory. Formaldehyde has, however, the properties of aldehydes in general, one of which is the power of condensation or polymerisation. It passes with extreme readiness into a much more inert form, para-formaldehyde, a body in which three molecules of the formaldehyde are grouped together. It is therefore possible that it may be prevented from exercising its deleterious properties by a transformation at once into this comparatively harmless modification. This will slowly decompose under proper conditions, giving off the free aldehyde.

Pollacci has stated that it is possible to extract formaldehyde from leaves. In his experiments he took such as had been exposed to light for a very considerable period and then macerated them in water. After a sufficient extraction he distilled the leaves, together with the water in which they had been steeped. The first portions of the distillate yielded reactions indicative of the presence of formaldehyde. His experiments do not enable us to say that free formaldehyde was there, for the more stable *para*-form would be likely to decompose during the distillation, so that the reactions would be explained without demanding the presence of the free aldehyde in the leaves.

But little success has attended hitherto the attempt to show that formaldehyde, in the presence of chlorophyll, or preferably, we may say, of chloroplasts, can give rise to carbohydrates. We have nothing more satisfactory than Bokorny's experiments, in which, after failing to set up photosynthesis in a filament of Spirogyra fed with formaldehyde, he succeeded when he supplied the alga with its compound with sodium-hydrogen-sulphite. Experiments on a more comprehensive scale, conducted on a variety of plants of different habits, are needed before we can regard the process as satisfactorily established.

We have further to pursue the problem by an inquiry as to the nature of the sugar first formed. Certain considerations lead to the view that it is probable that a sugar of the aldose type must be accompanied in the plant by a ketose. The hypothesis as stated by Baeyer, and so far accepted till quite recently, took no account of the latter. The aldose *grape sugar* was the one always suggested, and from this all others met with have been held to be constructed. The first appearance of a ketose, *levulose*, or *fruit sugar*, has been associated with the hydrolytic decomposition of *cane sugar*, itself constructed presumably from the grape sugar. I fear sufficient attention has not been paid to probability or to the normal course of chemical action in framing our hypotheses, for it is rather difficult to see how some of the transformations somewhat dogmatically affirmed can possibly take place. I may refer in passing to the statement that in the digestion of fat or oil during germination part of it is converted into starch or sugar.

But to return to the construction of sugar. The condensation of formaldehyde, which can be brought about by the action of basic lead carbonate, leads to the formation of several sugars, each yielding its characteristic osazone. How far the condensation in the plant follows this is still uncertain. It is quite possible that stages intervene between formaldehyde and sugar of any kind. It has been suggested that formaldehyde in the presence of water may under the conditions obtaining in the leaf give rise to glycolaldehyde, a body which forms sugar very readily indeed. The formation of sugar directly from formaldehyde is a much longer process and is attended with greater difficulty.

I may call your attention here to the views of Brown and Morris traversing the theory of the primary carbohydrate being grape sugar. In their classical paper on the chemistry and physiology of foliage leaves they have adduced strong evidence, based upon analyses of the sugar-content of leaves of *Tropæolum majus*, that in this plant at any rate the first sugar to be formed is cane sugar. Whether or no this is the case in plants generally cannot at present be said, though it appears from many considerations probable.

The part played by chlorophyll in photosynthesis has already been touched upon. Remarkably little is known about chlorophyll itself. It has so far been found impossible to extract it from the chloroplast without causing its decomposition, and hence our ideas of its constitution, such as they are, are based upon the examination of something differing in some not well-ascertained particulars from the pigment itself. A remarkable relationship is known to exist between the latter and iron, for unless this metal is supplied to a plant its chloroplasts do not become green. But the condition of the iron in the plant is uncertain; it seems probable that it does not enter into the molecule of the pigment at all. A remarkable series of resemblances between derivatives of chlorophyll and derivatives of hæmatin, the colouring matter of hæmoglobin, has been brought to light by the researches of Schunck and Marchlewski, which is very suggestive. The same leaning towards iron is found in the two pigments, but in the case of hæmatin our knowledge is further advanced than in that of chlorophyll. The iron is known to be part of its molecule. It can by appropriate treatment be removed, and a body known as *hæmatoporphyrin* is then formed, which presents a most striking similarity to a derivative of chlorophyll which has been named *phylloporphyrin*. The two pigments are almost identical in their percentage composition, the hæmatoporphyrin containing a little more oxygen than the other. Both seem to be derivatives of pyrrol. The most striking similarity between them is their absorption spectra, their ethereal solutions both showing nine bands of identical width and depth, those of hæmatoporphyrin being a little more towards the red end of the spectrum. Their solutions in alcohol and ether show the same colour and the same fluorescence. Though they differ in certain other respects, notably the facility with which they form crystals, it is impossible to deny that a close relationship seems probable. If this is established we may by analogy perhaps learn something about the part played by iron in the action of the chloroplast, which so far has proved as obscure as the relation of the metal to the pigment. It is very suggestive to recall the resemblances between the two pigments, the one playing so prominent a part in animal, the other in vegetable life. Both are associated with a stroma of proteid, or possibly protoplasmic, nature, in which a solution of the pigment is retained, apparently after the fashion of a sponge. Both are concerned in metabolic processes in which gaseous interchanges play a prominent part. Both are in some way dependent on the presence of iron for their individuality, even if iron is not actually present in the molecule of both. The iron being removed, the derivatives which are found are almost identical. Further researches may throw a light on this curious relationship, perhaps showing that chlorophyll may enter into a combination with carbon dioxide as hæmatin does with oxygen. Such a combination might well be the precursor of the decomposition of the carbon dioxide which has been already spoken of.

We meet with another pigment in many plants the physiological significance of which has in recent years begun to attract some attention. This is the red colouring matter, *anthocyan*, apparently related to the tannins, which is developed especially in the young leaves of shade-loving plants when they become exposed to illumination exceeding the intensity which they normally encounter. The formation of this pigment is greatest in tropical plants, where it is found usually in the epidermis of the young leaves, though in some cases it extends to the mesophyll as well. The pigment seems in some way to be supplementary to chlorophyll, for its absorption spectrum shows that it allows all the rays useful in photosynthesis to pass through it. It is unlikely that it takes any share in photosynthesis. Several theories have been advanced to explain its presence; it may be simply to protect the delicate cells from the destructive action of too intense light, or to avert the evil of overheating from the solar rays. It has been suggested that certain rays hinder the translocation of starch, and that the pigment shields the cells from the incidence of such rays. Again the view has been advanced that the red colour is important in accelerating the development of diastase from its antecedent zymogen, which has been found to take place under the influence of the rays of a certain region of the spectrum. While all these views have been advanced, however, there is little positive information bearing upon either the formation or the function of the pigment.

Very little progress has been made with the problem of the construction of proteid matter in the plant, which still confronts us. The question of its relation to the mechanism of photosynthesis has received some attention without leading to any satisfactory conclusion. Winogradski's success in cultivating the nitrate bacteria upon purely inorganic matter reveals an unexpected constructive power in some forms of vegetable protoplasm. The question of the energy made use of in proteid construction is in an equally unsatisfactory condition. Laurent, Marchal, and Carpiaux have stated that the rays of the violet and ultra-violet region of the spectrum are absorbed and devoted principally to the construction of nitrogen compounds from the nitrates, or the compounds of ammonia, which are absorbed by the plant, while the intervention of the chlorophyll apparatus is unnecessary for this purpose. The experiments which they give in considerable detail upon this absorption carry much weight and appear conclusive. Unfortunately other observers have failed to confirm them, so that at present the matter must be left open.

Among the problems connected with the nutrition of the plant, the part played by alcohol has recently come into prominence. Alcohol was originally associated only with the lower fungi, and especially with the yeast plant. Biological problems of grave importance arose in connection with the Saccharomyces, apart from what seemed at first the larger question, viz., the nature of fermentation. A prolonged study of the latter phenomenon led Pasteur to the view that alcoholic fermentation is only the expression of the partial asphyxiation of the yeast, and its efforts to obtain oxygen by the decomposition of the sugar. It is hardly necessary here to remind you of the controversies that centred about the question of fermentation and the theories held and abandoned as to its cause. The biological phenomena have, however, a claim now upon our attention in the light of some very remarkable researches that are calling for our attention and criticism to-day. Pasteur's explanation of the behaviour of the yeast was, as we have seen, such as to connect it with the respiration of the plant. When oxygen was withheld from active yeast 60–80 parts of sugar disappeared for one part of yeast formed. When oxygen was present not more than ten parts of sugar were decomposed for the same amount of yeast production. Undoubtedly the stimulus of asphyxiation materially stimulated the yeast metabolism.

But certain observations did not agree with Pasteur's explanation. An energetic fermentation takes place in the presence of oxygen, the plant multiplies extremely quickly, and its metabolism appears very active. Schützenberger argued against Pasteur's explanation with some force, emphasising these points of disagreement between his hypothesis and the facts, and claimed that the matter rather concerned nutrition than respiration. He based his view on experiments carried out to ascertain how respiration was affected under changed conditions.

The results he obtained were briefly the following:—

(1) In a watery liquid without sugar, but containing oxygen in solution, the quantity of oxygen absorbed in unit time by a gramme of yeast is constant, whatever proportion of oxygen is present.

(2) In a saccharine liquid containing albuminous matter as well as sugar, and with oxygen in solution, the same result is obtained, except that the quantity absorbed in unit time is greater.

(3) In two digestions carried on side by side for some time, one being supplied continuously with oxygen and the other deprived of it, the former produced most alcohol.

If the decomposition of the sugar had been the result of the respiratory activity of the yeast cells at the expense of the combined oxygen of the sugar, it would seem that fermentation should either not have taken place at all in the presence of free oxygen, or that it should have been much less than in the other case, whereas the reverse is what is found. Hence Schützenberger advocated the view that the sugar is alimentary and not respiratory.

Certain facts more recently discovered support strongly the view that the nutrition of the yeast is the chief object of the process normally, though we cannot deny that when partial asphyxiation sets in fermentation is resorted to by the plant in its difficulty, that it may obtain the energy normally supplied by the respiratory processes. The mode of decomposition of the sugar, however, the formation of alcohol and carbon dioxide, raises a question as to the exact form in which the nutritive material is supplied to the protoplasm.

Of these more recent discoveries the work of Devaux on the trunks of trees may be mentioned first, as it seems to point to a similar problem to the one connected with yeast. Devaux examined the composition of the air in the interior of woody stems growing under normal conditions, and found that the proportion of oxygen it contains often sinks as low as 10 per cent., while in a few cases, in the most internal part of the tree, he found this gas to be entirely absent. The disappearance of oxygen becomes easier with every increase of temperature. This partial asphyxiation is attended by the formation of alcohol in the struggling tissue, the spirit being detected by cutting up the branches of the trees and distilling them with a large excess of water. Devaux's experiments were made upon a considerable variety of trees, among which may be noted *Castanea vulgaris, Pyrus domestica, Alnus glutinosa, Ulmus campestris, Sambucus nigra*, and *Ficus Carica*.

Similar results have been obtained by Mazé in some researches on seeds. When a number of these are submerged in water, micro-organisms being properly guarded against, they do not readily germinate, but their weight nevertheless somewhat rapidly diminishes. In some of Mazé's experiments with peas he ascertained that this diminution was attended by a considerable formation of alcohol. Three parcels of forty peas were examined, weighing respectively 10, 17, and 27 grammes, and the experiments lasted six, twelve, and twenty-seven days. He found the proportion of alcohol to the original weight of the peas was 2·34, 4·63, and 6·56 per cent. As the peas were submerged, and so kept out of contact with air, it seems possible to suppose we have here again an effect of asphyxiation. Other experiments, however, make this view unsatisfactory. He germinated twenty peas at 22° C. for seven days under normal conditions, till their axes were about 1½ inch long. He then covered them with water, in some cases leaving the terminal bud exposed to air. The development of the submerged plants stopped at once, and at the end of five days the liquid contained 130 milligrammes of alcohol. The seedlings whose terminal buds were exposed to the air continued to grow without showing any disturbance. Mazé concludes that the alcohol produced was utilised by them in their growth, and suggests that it is a normal and necessary product of the digestion of carbohydrate material in seeds in course of development.

He goes on to show that alcohol can be demonstrated to be present in plantlets that have germinated for forty-eight hours at 23° C. under normal conditions.

Another worker of great eminence who has found similar conditions to exist in normal vegetation is Berthelot. He put blades of wheat and leaves of the hazel in flasks, displaced the air by hydrogen, and distilled. In the case of the wheat he heated the flask to 94° C., in that of hazel he conducted the distillation by passing steam through the flask. In both he found the distillate contained alcohol. The quantity was not large, but still measurable; from 10 kilos. of leaves he obtained 10 grammes of alcohol.

Mazé claims to have found alcohol under normal conditions in the stems and leaves of the vine.

Mazé finds further that the weight of a seedling of maize approximates at any moment during the early stages of germination to half that lost by the reserve store in the endosperm.

From his experiments, and those of the other authors alluded to, he concludes that alcohol is formed in the living cells of seeds at the expense of grape sugar by virtue of a normal diastasic process, which makes them approach yeast cells more closely than has been suggested by any of the experiments hitherto published. We may inquire further how far the evidence points to the probability that the olecule of sugar is split up in that way into alcohol and carbon dioxide, and at the alcohol is the nutritive part of the sugar molecule. Certainly Mazé's xperiments on the submerged seeds with the plumule exposed above the water re not inconsistent with that view. Duclaux has spoken more definitely still n this point, and has said that the alcohol formed becomes a true reserve aterial to be used for nutriment.

We have, however, further evidence that to some plants, at all events, lcohol is a food. Laborde has published some researches conducted upon a ungus, *Eurotiopsis Gayoni*, which point unmistakably to this conclusion. He ultivated it in a solution containing only the mineral constituents of Rawlin's fluid nd a certain percentage of alcohol, usually from four to five per cent. The plant rew well, forming little circular patches of mycelium, which enlarged radially s the growth progressed. The mycelium became very dense in the centre of the patches, and the fungus evidently thrived well. As it grew the alcohol slowly disappeared, the rate being about equal to that of sugar in a similar culture in which this substance replaced the alcohol. The mycelium in some experiments was cultivated quite from the spores. Eurotiopsis is a fungus which has the power of setting up alcoholic fermentation in saccharine solutions. When cultivated in these alcohol is accordingly produced, and subsequently used, but the growth of the mould is not so easy under these conditions as when the alcohol is supplied to it at the outset.

Duclaux has shown that in the case of another fungus, the well-known *Aspergillus niger*, though alcohol kills it while it is in course of germination from the spore, it can utilise for nutrition 6·8 per cent. when it becomes adult, continuing to grow, and putting out aërial hyphæ. Eurotiopsis is more pronounced in its liking for alcohol, for it thrives in a mixture containing 10 per cent.; even if submerged entirely it continues to grow and flourish in an eight per cent. solution.

The peculiarity relates only to ethyl alcohol; methyl alcohol will serve as a nutritive medium for only a little time, sufficient only for the commencing development of the spores into a mycelium and disappearing very slowly from the culture fluid. The higher alcohols, propyl, butyl, and amyl, not only give no nourishment, but are poisonous to spores. A very small trace of any of them can be used by the adult mould.

Laborde claims to have established as the result of his investigations that Eurotiopsis normally makes alcohol from the sugar to nourish itself with it, just as yeast makes invert sugar from cane sugar because it is the nutritive material it likes best. The enzyme zymase is present in the fungus and plays the part of an alimentary enzyme. Its consumption lasts twice as long as that of a corresponding weight of glucose; it can serve twice as long for the nutrition of the same weight of plant.

These remarkable results lead us to the consideration of the mode in which the carbohydrates, and particularly the sugars, are assimilated by the plant. We have held the view that the sugar molecule is capable of entering with little if any alteration into that of protoplasm. We have found no direct evidence bearing upon its fate. It is possible to detect sugar in the axis of a plant till quite near its growing point. Then the reaction ceases to be obtainable, and we know that assimilation is taking place. But we have still to investigate the steps, no very easy problem to undertake. May it possibly be that it is the alcohol moiety of the sugar which the protoplasm takes up, part of the carbon dioxide evolved by the growing organ being an expression, not of respiration, but of a fermentation preliminary to assimilation?

But I feel I have dealt at sufficient length with this question. I pass, therefore, to consider briefly another nutrition problem of a rather different kind. The germination of seeds is a question that might be thought to have been fairly settled by the investigations of the latter half of the last century. We have come to the conception of the seed as fundamentally a young embryo lying quiescent within its testa, and provided with a store of nourishment deposited either within its own substance, or lying round it in the tissues vaguely named endosperm or perisperm. The nourishment has been held to be practically ready for its use, needing only a certain amount of enzyme action to be applied to it to convert the food store from the reserve to the nutritive condition. We have recognised here starch, proteids, and glucosides, and have ascertained that the embryo can furnish the appropriate enzymes for their digestion. Each reserve store has apparently been quite independent of the rest, and the embryo has had control of the whole.

Certain considerations, however, lead us to the view that for albuminous seeds at any rate this mode of looking at the matter is no longer satisfactory. We may first ask how far the embryo is the controlling factor in the digestion. Putting the matter in another form, is the influence of the parent plant lost when a stable store of food has been provided for the offspring, and does it leave its utilisation entirely to the latter? Is the gametophyte prothallus merely to become a dead or inactive structure as soon as it has developed its young sporophyte, or may its influence extend for the longer period of germination? There are many reasons for thinking this is the case. Indeed the view has been put forward by some observers at intervals for some years. Gris claimed to have shown it in 1864; but it was opposed by Sachs, who said that the enzymes which cause decompositions in the reserve materials are always formed in the young plant or embryo and are excreted by the latter into the endosperm. Some careful experiments on the point were conducted by Van Tieghem and were published by him in 1877. His work was carried out on the seeds of the castor-oil plant. He deprived the seeds of their embryos and exposed them for some weeks on damp moss to a temperature of 25–30° C. After several days of this exposure he found the isolated endosperms were growing considerably, and at the end of a month they had doubled their dimensions. In the interior of the cells he found the aleurone grains to be gradually dissolving, and the oily matter to be diminishing, though slowly. The dissolution extended throughout the mass of the endosperm, and was not especially prominent in the side that had been nearest to the cotyledons. He noted, too, that though starch did not normally appear in the germinating endosperm, under the condition of non-removal of the products of the decomposition, it did appear in the cells in the form of small grains, though not till after several days had elapsed. Van Tieghem also observed that the progress of the decompositions could be arrested and the endosperms made to reassume a quiescent condition, and that then the aleurone grains again became formed, though in less quantity than before.

In some experiments on Ricinus which I carried out in 1889 I found much the same sequence of events as Van Tieghem had described. The endosperm unquestionably became the seat of a renewed metabolism, in the course of which many interactions between the various reserve materials became noticeable. It was remarkable that the activity of this metabolism was much more pronounced when the embryo or parts of it were left in contact with the endosperms.

An observation of a similar character has been made by Haberlandt and by Brown and Morris in the case of the seeds of grasses. The conversion of the reserve cellulose of barley grains has been shown by these observers to be the result of the action of an enzyme *cytase*, which is secreted largely by the so-called aleurone layer, which is found surrounding the endosperm, immediately underneath the testa.

Recently my own work has been bearing on this question, particularly as regards the behaviour of the seeds of Ricinus during germination. The reserves of this seed are mainly composed of oil and aleurone grains, hardly a trace of carbohydrates being present. At the onset of germination there is a remarkable appearance of both cane sugar and glucose, which increase as the oil diminishes. The old view advanced to explain this fact has been the transformation of the oil directly into the sugars or one of them, a theory which it was difficult to reconcile with the chemical possibilities of oil. I have found that side by side with the appearance of the sugar we have also the formation of a considerable quantity of lecithin, a fatty body containing nitrogen and phosphorus. The seed contains a comparatively large amount of phosphorus in the form of the well-known globoids of the aleurone grain, a double phosphate of calcium and magnesium. The occurrence of this body points to a considerable interaction of various substances existing in the seeds, the phosphorus apparently coming from the globoids and the nitrogen from the proteids. Instead therefore of the fat being transformed into sugar it seems certain that a very considerable metabolism is set up, in which the various constituents of the endosperm interact very freely together. I am informed by Mr. Biffin, who has investigated the histological changes accompanying the germination, that the protoplasm of the endosperm cells appears to increase in amount very greatly during the early stages. The observations suggest a very vigorous resumption of metabolic activity by the cells of the endosperm, in the course of which the various reserves are brought into relation with the living substance of the cells and a number of new products are formed to minister to the nutrition of the growing embryo. The formation of the sugars may more probably be referred to the renewed activity of the protoplasm of the parent gametophyte than to a direct transformation of the fat under the influence of the embryo. Further researches upon a large variety of seeds appear necessary to give us a true idea of the chemical processes of germination. What now appears probable in the case of fatty seeds may prove to be true also in the case of those which have other varieties of reserve material.

I have already alluded to the problems concerning the electrical phenomena presented by the plant at rest and during activity. Very little work has so far been done in this direction, and our knowledge of the subject is materially less than that concerning similar phenomena in muscle and nerve. Still a beginning has been made, and we have observations on record due to Waller and to Bose which are of the greatest interest, not only because they show a great correspondence in behaviour between animal and vegetable structures, but on account of their possible importance in determining the character of many of the metabolic processes and the forces at work in the tissues.

Some very striking results were only a few months ago published by Bose on the electric response in ordinary plants to mechanical stimulation. He arranged a piece of vegetable substance, such as the petiole of the horse-chestnut, or the root of a carrot or a radish, so that it was connected with a galvanometer by two non-polarisable electrodes. The uninjured tissue gave little or no evidence of the existence of electrical currents; but if a small area of its surface was killed by a burn or the application of a few drops of strong potash, a current was observed to flow in the stalk from the injured to the uninjured area, just as is the case in animal tissue. The potential difference in a typical experiment amounted to 0·12 volt. The tissue was then stimulated, either by tapping or by a torsion through a certain angle, and at once a negative variation or current of action was indicated, the potential difference being decreased by ·026 volt. Very soon after the cessation of the stimulus the tissue recovered and the current of rest flowed as before. Bose's investigations extended considerably beyond this point, and established a very close similarity in behaviour between the vegetable substance and the nerves of animals. Summation effects were observed, and fatigue effects demonstrated, while it was definitely shown that the responses were physiological. They ceased entirely as soon as the piece of tissue was killed by heating.

This remarkable demonstration of similar electrical properties to those possessed by nerve strengthens very greatly the view of the conduction of stimuli in the plant by means of the protoplasmic threads which have been demonstrated by Gardiner and others to exist throughout the plant, uniting cell to cell into one coherent whole.

Much remains to be done in this field; indeed, not more than a beginning has been made. The electrical accompaniments to response to stimuli have been investigated by Burdon Sanderson in the case of *Dionæa*, but many other instances are still awaiting examination. The peculiar phenomena of electrotonus and their relation to stimulus have so far only been observed in animals.

These observations strengthen considerably the view of the identical nature of animal and vegetable protoplasm which has in recent years come into prominence, and which is receiving more and more support in all directions.

These electrical currents, following mechanical action, which no doubt is accompanied by chemical change, make us ask whether electrical phenomena do not in all probability accompany the slow chemical actions which we call metabolism. The view that electrical energy is concerned in the processes of photosynthesis, suggested in an earlier part of this Address, is certainly not weakened by a consideration of these phenomena.

The probability of the transmission of stimuli through vegetable tissue along the protoplasmic threads, extending from cell to cell, has been supported during the last year or two by some remarkable observations claimed to have been made by Nemec on certain roots and other organs. He says he has succeeded in demonstrating a continuous fibrillar structure in the protoplasm of the cells, fibrils passing along it in a longitudinal direction and apparently connecting the protoplasm of a longitudinal series of cells into a conducting chain. These conducting strands extend between the sensitive region—*e.g.*, the tip of the root—and the region which is growing, and which is caused by the stimulus to curve. Nemec says that these conducting strands can be made evident by the use of appropriate staining reagents. They vary in number and position, but appear to be confined to sensitive and motile organs.

It is clear that the matter cannot rest where it is. The statements made by Nemec call for investigation by both histological and physiological methods. It is possible that appropriate reagents may lead to the recognition of structure in what has been hitherto regarded as undifferentiated protoplasm.

Before concluding this Address I may call attention to the vast field opening up in connection with the pathology of plants. The work done by our predecessors has been more largely work on the morphological peculiarities of various fungi than upon the physiological changes which constitute pathology, properly so called. It is only recently that attention has been given to the broad questions of disease in plants. Even now, however, certain advances have been made, and the direction of research is taking shape. In the science of pathology little in recent years has been so fascinating as the question of immunity against the attacks of certain diseases, either hereditary or acquired. It has been bound up with the very large question of toxins and their attenuation, their opposites, the antitoxins, and matters of a similar nature.

Great results have been obtained in human pathology, with which it is not for me to deal. I mention them here because we are face to face with the possibility of treating some of the diseases of plants in a similar way, and perhaps on the threshold of very far-reaching discoveries.

I may call attention to the researches of Ray and of Beauverie upon the general question of plant infection, and especially upon a disease set up by a fungus known as *Botrytis cinerea*, which attacks grapes, begonias, and other plants. The fungus exists in three forms, one of which is a harmless saprophyte, another a destructive parasite, and a third intermediate between the two. The first is a very common fungus, developing on decaying plants and bearing ordinary gonidia or spores. The second is completely filamentous and bears no reproductive organs. It is produced when the air is heavily charged with moisture and the temperature high, conditions of common occurrence in forcing houses. The third is an attenuated form intermediate between the other two. It bears gonidia like those of the first, and in addition others which germinate without falling off the parent plant and elongate into long threads. Many plants can bear the invasion of this plant without suffering greatly, though it cannot be called harmless. It occurs chiefly when a high temperature is associated with a considerable amount of moisture in the air.

It is not difficult to cultivate this attenuated form of the Botrytis in sterilised soil. Beauverie describes one experiment made with it which is very striking. Damp earth was sterilised in a Petri dish of large surface, sown with spores of the Botrytis, and kept at a temperature of about 16° C. After three days the surface of the dish was covered with a loose mycelium, which bore numerous gonidiophores. The fungus was allowed to grow for some time under these conditions, and the infected earth was then transferred to fresh pots in which were placed cuttings of begonias. The plants grew well and were not sensibly affected by the presence of the fungus in the substratum or in its surface. Placed subsequently in conditions which were eminently suitable to the development of the parasitic form, they resisted its action perfectly, though control plants which had not been cultivated in the ground infected by the attenuated form were killed very quickly. From their experiments the authors claim to have shown that the form of *Botrytis cinerea* intermediate between the gonidial and the sterile form can make plants immune to the attacks of the latter.

Researches of a somewhat kindred nature dealing with the infection of particular plants by specific fungi have been communicated recently to this Section by Professor Marshall Ward in his paper read last year on the Bromes and their brown rust. They brought to light many very important facts connected with the question of adaptive parasitism and immunity. Few questions in vegetable physiology can compare in economic importance with these when we think of their possible development in relation to agriculture.

I have now somewhat hurriedly surveyed certain parts of the field of vegetable physiology. It has been impossible in an Address like this to do more than indicate what seem to me some of the more important problems awaiting investigation. May we hope that all such work will be vigorously conducted, but that the conclusions reached will be scrutinised with the greatest care and subjected to repeated examination? Great hindrances to the advance of the science resulted from dogmatic assertions made by eminent men in the past, their personal influence having led to their conclusions, not altogether accurate, being nevertheless almost universally accepted. Many years subsequently these conclusions have needed re-examination, the result being the destruction of a whole fabric that had been reared upon this unworthy foundation. I may close, as I began, by an appeal to the younger school of botanists to take some of this work in hand, and by assiduous and critical experiment and observation to contribute to the solution of the problems pressing upon us in this field.

The following Papers and Reports were read:—

1. *Exhibition of Forms of* Erica Tetralix *from Connemara.*
By Professor I. BAYLEY BALFOUR, *F.R.S.*

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2. *Notes on a Census of the Flora of the Australian Alps.* (*Part I.*)
By JAMES STIRLING.

In preparing this census, with accompanying notes on the orders represented, the author has in view an inquiry into the origin and distribution of the mixed types of plants now growing on the highest altitudes over south-east Australia, and the subsequent correlation with other Alpine and the Tertiary floras of the region.

From 1875 to 1888 he collected 1,019 species of plants, of which 678 were Phanerogams and 341 Cryptogams.

Over one-tenth of the total of the plants of the Australian continent are found in the Australian Alps at elevations between 2,000 and 7,000 feet.

The area investigated includes the main watershed line, separating the streams flowing northerly into the Murray from those flowing southerly into the Gippsland Lakes and the Southern Ocean—*i.e.* from the heads of the Yarra River on the west to the Kosciusko plateau on the north-east, over a distance of 15,000 square miles. It embraces also the high tablelands, between 4,000 and 6,000 feet, which form expansions of the lateral watershed line.

An outline of the physical features is given with reference to the geological structure and to the climatic conditions of the area.

The outlines of a number of the principal mountains are mainly of the relict class of Professor Geikie, formed by denudation and erosion from an extensive tableland which covered the greater part of the area during Eocene and Miocene times.

The adjacent valleys of the high lateral tablelands have been eroded down to a depth of 4,000 feet below the original level of the older Tertiary valleys. Some of the high peaks may be included in the Tectonic class, such as Mount Cobberas, &c.

An idea of the general botanical features is given by referring to the character of the principal species of each natural order now flourishing at elevations between 5,000 and 7,000 feet, which is referred to as the Alpine area; that between 2,000 and 5,000 feet is called sub-Alpine.

It is shown that commingled with a majority of Antarctic types of plants at the higher altitudes are also some European, South African, and Polynesians, thus indicating oscillating land surfaces and alternating climatic conditions, permitting waves of vegetation, or the migration of plants across land surfaces now submerged, since early Tertiary times, when the vegetation of a tropical character overspread the area.

The dominating influence of climate in the evolution of varieties of plants over that exerted by geological formations, or the soils derived therefrom, is especially referred to, and numerous cases cited, particularly in regard to the eucalyptus vegetation.

The strongest affinity undoubtedly exists, as pointed out by Sir J. Hooker, with the Tasmanian flora, and Antarctic types prevail, although there are not wanting evidences of affinity with South Africa, Polynesia, and the mountains of New Guinea and Morocco. The whole of the evidence now available to date confirms the original forecast of Sir J. Hooker, that the antecedents of the peculiar Australian flora, as a whole, may have embraced an area to the west of the present Australian continent analogous with South Africa, and that the bond of affinity between the Antarctic and South African floras indicate them as members of one great vegetation which may have covered as large an area as the European does in the northern hemisphere. This would also imply, in my opinion, not only a land connection between Australia and South Africa by way of Antarctica, but also land connections to portions of Polynesia, New Zealand, and South America, during Tertiary times.

The orders represented by the greatest number of species, taking the first twelve of the whole flora, are:—

Musci	96
Leguminoseæ	76
Compositeæ	76
Filices	50
Myrtaceæ	42
Cyperaceæ	36
Gramineæ	35
Lichens	35
Proteaceæ	30
Orchideæ	26
Rutaceæ	24
Labiateæ	17

Above the 5,000-foot level the numerical relations of the species to the orders are as follows:—

Lichens	35
Compositeæ	28
Musci	25
Gramineæ	22
Leguminoseæ	19
Rutaceæ	11
Epacrideæ	9
Myrtaceæ	8
Cyperaceæ	7
Proteaceæ	7
Scrophularineæ	7
Caryophylleæ	7

A comparison with the florula of a British area, the Clyde watershed and the Isle of Arran, visited by the author, shows that there are thirty-six natural orders, 156 genera, common to the Australian Alps and this area, and sixty-eight identical species. A considerable number are, however, immigrants to the Australian area.

The proportion between the arboreous, semi-arboreous, or shrubs, and the herbaceous plants, excluding the Gramineæ and Cryptogams, is given.

3. *On Luminous Bacteria.* *By* J. E. BARNARD *and* Professor ALLAN MACFADYEN, *M.D.*

Many instances of light-production occur in nature amongst plants and animals. This luminosity is most strikingly exhibited by marine animals and by minute vegetable-cells belonging to the group of the bacteria. Light-production by living protoplasm is a process intimately bound up with the life of the organism, as in the case of the luminous bacteria. The luminosity of mineral and other inert bodies is dependent on an extraneous light source.

Amongst light-producing organisms our knowledge of the process is most exact in the case of the bacteria. Their simple semicellular structure, and the fact that modern bacteriological methods enable us to isolate and study particular organisms, renders it somewhat more easy to study the conditions under which light-production can best occur. The observations which are embodied in this paper were made on luminous bacteria. These organisms are to be found mainly in sea-water and on dead marine animals. They are widely distributed in this respect. We have obtained and studied the most important types. About twenty-five varieties have been described, but it is probable that some of these are very closely related, if not identical. A hitherto undescribed form has been isolated from sea-water in the course of investigations made by one of us at Plymouth. It belongs, like most of the other species, to the group of the bacilli. The temperature conditions as regards growth vary considerably, and range from zero to 37° C.

The luminosity of the sea is mainly due to higher forms of marine life and not to bacteria, at any rate in northern latitudes. On the other hand the phosphorescence of dead objects, such as fish, &c., is due to bacterial forms of life.

We have not been able to confirm the statements that luminous bacteria have direct infective properties as regards crabs and other marine animals.

These organisms require particular and exact conditions in order to exhibit their luminous properties. They must have a suitable nutrient soil containing such proportions of salts as shall render the medium isotonic. For example, sodic chloride, if present to the extent of 3 per cent., will render the organisms luminous and ensure their remaining so for some time. In this manner they can be readily cultivated and studied in the laboratory.

The luminosity appears to be a function of the living cell and can be disturbed by any process which interferes with the vitality of the cell itself. The dead cell is non-luminous, whilst antiseptics which kill the cells inhibit at the same time their luminosity.

A supply of free oxygen is essential; in the absence of oxygen the organisms live but are non-luminous. There is no evidence of a bacterial product as the source of the light. The process appears to be the result of an active oxidation occurring within the cell. The light produced is confined to a small portion of the visible spectrum, and invisible radiations have not been detected. As the spectrum of none of these luminous organisms extends even to the red, it may safely be assumed that no heat radiations are emitted. The light is produced without heat. No invisible radiations allied to the X-rays were detected. Photographs have been obtained by the aid of the light emitted by these organisms. The time-exposure required is, however, considerable.

An exposure to the temperature of liquid air does not destroy the luminosity of the organisms. It has been found possible to triturate bacteria at the temperature of liquid air by means of special methods devised at the Jenner Institute of Preventive Medicine. The luminous bacteria mechanically broken up in this manner ceased to phosphoresce. The luminosity, therefore, is due to the vital processes of the cell, and essentially depends for its origin on the *intact* organisation of the cell.

We have brought these results forward because this interesting group of organisms have not hitherto been studied in this country so far as we can trace.

4. *Report on the Respiration of Plants.*—See Reports, p. 472.

5. *Report on the Cyanophyceæ.*—See Reports, p. 473.

6. *Report on the Collection and Preservation of Botanical Photographs.* See Reports, p. 471.

7. *Exhibition of some Characteristic Australian Plants.*
By THOMAS STEEL.

FRIDAY, SEPTEMBER 12.

The following Papers were read :—

1. *Electric Response of Ordinary Plants under Mechanical Stimulus.*[1]
By Professor JAGADIS CHUNDER BOSE, *M.A., D.Sc.*

Electric response has been found by Burdon Sanderson, Munck, and others to occur in sensitive plants. The present investigation was directed to find whether these responses were confined to plants which exhibit such remarkable movements, and whether they could not also be obtained from ordinary plants where visible movements are completely absent. The inquiry had the further important object of determining whether throughout the whole range of response phenomena a parallelism in every detail could be demonstrated between the animal and vegetable.

Method of experiment.—For exhibition of electric response a non-electrical form of stimulus is preferable. A mechanical tapper gives isolated or superposed stimuli. This form of stimulation labours under certain disadvantages: there is an unknown loss of energy due to rebound; the plant subjected to repeated blows is liable to be injured, and this might give rise to variation in the successive responses. A more perfect method of stimulation, *i.e.*, of vibration, has been devised by me. The intensity of stimulation is found to depend on the amplitude of vibration. In order to maintain the effective intensity of stimulus constant it is necessary (1) to maintain the vibration amplitude constant, (2) the period of vibration constant.

As regards the obtaining of response the method of injury or negative variation may be employed. But a far more perfect plan has been devised by me—that of block.

The advantages of this method are: (1) The response is obtained under perfectly normal conditions, the plant being left intact; (2) every experiment may be duplicated by corroborative reversal experiment. Many investigations which cannot be attempted by the method of injury can be easily carried out by the method of block.

As regards the record of responses the following device is very perfect, and enables demonstration before a large audience. Twin aluminium cylinders are kept revolving at a uniform rate by clockwork, an endless band of paper passing over the cylinders. The moving galvanometer spot of light is at right angles to the motion of the recording paper and is followed with a pen.

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[1] For a more complete account see the following: Bose, 'Response of Inorganic Matter to Stimulus' (Friday Evening Discourse, Royal Institution, May 1901); 'Electrical Response in Ordinary Plants under Mechanical Stimulus' (*Journal Linnean Society*, March 1902); *Response in the Living and Non-living* (Longmans, Green, & Co.).

As with different animal tissues, three types of responses have been obtained with plants: (1) Uniform responses; (2) responses exhibiting fatigue; and (3) responses exhibiting 'staircase' effect. Singly ineffective stimuli become effective by summation. Under continuous stimulation a maximum effect is obtained. Increasing stimulus produces increasing response, which tends to approach a limit. As regards the effects of temperature on response, the response is at its maximum at the optimum temperature, the response declining above and below the optimum. The response disappears at the death-points. By no other method can the death-points be determined with such an exactitude. Under certain conditions a diphasic variation is obtained. Ordinary plants exhibit electrotonus. Anæsthetics gradually depress response; poisons abolish it altogether. The effect of the latter sometimes depends on the dose, a small dose producing the opposite effect of stimulation. These and other effects obtained with plants are strictly correspondent with the effects obtained in the animal tissues.

2. *The Movements of the Flower-buds of* Sparmannia africana.

By Rina Scott.

Sparmannia africana is a common greenhouse plant, which was introduced from the Cape into Europe in 1790.

It is well known to the botanist on account of the curious movement of its stamens, which when touched gradually move away from the stigma, leaving it exposed and ready for fertilisation by bees. A paper was written on the subject by Ch. Morren as early as 1841.

The following observations are on the movements of the flower-buds and flowers up to the time of the setting of the fruit.

At first the buds hang all in one plane; each bud has a joint on the stalk, which is much swollen below the flower. This joint regulates the position of the bud, flower, or fruit at different times of its development, and it is here that the fruit is detached when ripe.

Three complete inflorescences were drawn from bud to fruit, from February 25 to May 1902, every day and every night, and from these data the following results were obtained.

The flower-stalk circumnutates and grows during flowering on an average 1¾ in. (4·4 cm.) in height; the flower-bud rises 3 inches (7·5 cm.) in height.

The buds rise one by one from the drooping position to the horizontal; then make a sharp curve inwards, and just before flowering the bud hangs down in an exactly vertical position, which is attained by the movement at the joint. The flowers open during sunlight at a temperature not below 60° F. (15·5 C.), so that on a cold day perhaps only one flower, while on a hot day three or four may be open at the same time.

On a sunny, hot day the flowers open very quickly. One bud began opening at 12 P.M., temperature 70° F. (21·1 C.), and was completely open at 2.5 P.M., 72° F. (22·2 C.); asleep at 6 P.M. The bud, however, will not go on opening if for any reason the temperature falls below 60° F. (15·5 C.). One bud began opening at 10.50 A.M., temperature 72° F. (22·2 C.), on a bright, sunny day; at 11 A.M. it had put up two sepals; at 12.10, 66° F. (18·8 C.), it was putting up a third, when a hailstorm reduced the temperature below 60° F. (15·5 C.); at 12.40 P.M., 66° F. (18·8 C.), it put up a third sepal, when another hailstorm at 2.20 again reduced the temperature, and the flower closed for the night.

Every night the flowers go to sleep; the youngest go to sleep first. The flower is bent downwards at the joint and first the petals close, one at a time, and then the sepals. A young flower may go to sleep as early as 6 P.M., while an old one may not be asleep by 10.30 P.M.

The usual hour for waking is about 9 A.M. The flower begins opening soon after sunrise. On March 23, at 6.40 A.M., the petals began to expand, temperature 48° F. (9° C.), and the flower was full open at 9 A.M. This is illustrated by a long series of drawings.

The flowers reopen for several days. The first day the stigma is short and the pollen unripe, petals curved back; the second day the stigma has grown as long as the stamens, and the pollen is ripe; the third day the petals remain flat open, and there is a profuse quantity of pollen; during this time the flower gradually takes up a vertical position, pollen often being formed for five or six days. Then, if fertilised by bees, the flower-stalk falls again into the horizontal position, from which it rises again as the fruit ripens. The fruit does not ripen easily in England. Bees had to be introduced into the greenhouse on a day when the temperature was above 70° F. (21·1 C.) The fruits ripen and fall off at the joint. The seeds were germinated and the seedlings drawn.

The behaviour of the flowers in rain was also described.

3. *On the Germination of Fatty Seeds.*

By Professor J. REYNOLDS GREEN, *F.R.S., and* H. JACKSON.

4. *On the Suspension of Life at Low Temperatures.*

By ALLAN MACFADYEN, *M.D., and* SYDNEY ROWLAND, *M.A.*

Our first experiments were made with organisms possessing varying degrees of resistance, the extremes in this respect being represented by the sensitive spirillum of cholera asiatica and the resistent spores of Bacillus anthracis. Ten organisms altogether were used and cooled down to – 190° C., in the first instance for twenty hours, and eventually for seven days. These exposures did not produce any appreciable impairment in the vitality of the organisms, either as regards their growth or their characteristic physiological properties, such as pigment and gas production, pathogenicity, &c. Amongst the organisms tested were photogenic bacteria, and these likewise preserved their normal luminous properties; and we were able, through the kindness of Professor Dewar, to apply a still severer test—namely, an exposure to the temperature of liquid hydrogen (about – 252° C.), a temperature which is as far removed from that of liquid air as is that of liquid air from the average summer temperature. Ten hours' exposure to this temperature had no appreciable effect on the vitality of the micro-organisms tested. At such temperatures it must be assumed that the chemical metabolism of the cell ceases, in the absence of heat and moisture. At the same time it appeared to us advisable to test the influence of a *prolonged* exposure to low temperatures on the vitality of cells. The experiments were conducted with the aid of the liquid air plant at the Jenner Institute of Preventive Medicine. The organisms employed were the B. typhosus, B. coli communis, Staphylococcus pyogenes aureus, and a saccharomyces. The bacteria were suspended in small loops of platinum wire or on cotton-wool swabs, and directly immersed in the liquid air. The yeast, washed and pressed, was wrapped in rice-paper, and likewise directly immersed in the liquid air. Samples were taken and tested at intervals for a total period of six months. In no instance could any impairment of the vitality of the organisms be detected. The yeast gave a good growth, and exhibited its fermentative powers unaltered; the typhoid bacillus retained its pathogenic and other properties; the Staphylococcus aureus gave a characteristic pigment growth, and the colon bacillus responded to all the typical tests that were applied to it. Judging by the results, the experiments might have been prolonged for a much longer period than six months without appreciable influence on the vitality of the organisms in question.

The ordinary manifestations of life cease at zero, but at – 190° C. we have every reason to suppose that intra-cellular metabolism must also cease—as a result of the withdrawal of two of its cardinal physical conditions—heat and moisture.

It is difficult to form a conception of living matter under this new condition, which is neither life nor death, or to select a term which will accurately describe it.

It is a new and hitherto unobtained state of living matter—a veritable condition of *suspended animation.*

5. *Resistance of Seeds to High Temperatures.* *By* Henry H. Dixon, *D.Sc.*

Various experimenters have investigated the limits of temperature which spores of the lower plants and animals can withstand. The results they have obtained show that these spores, if dry, can germinate after exposure to the lowest temperatures obtainable, while the upper limit for similarly dried spores lies between 100° C. and 130° C.

For seeds of the higher plants also it has been more recently shown that the lowest temperatures available are without harmful effects. This note contains an account of some experiments on the maximum temperatures seeds can withstand and after which they will retain their germinative power.

Before exposure to the high temperatures the seeds were either desiccated over sulphuric acid, or dried in an oven the temperature of which was gradually raised to 90° C. After desiccation the seeds were exposed for at least one hour to the higher temperature. After exposure the seeds were sown on moist sand. The following temperatures were obtained as the highest after exposure to which the seeds of the species mentioned could germinate:—

Mimulus moschatus	105° C.	Medicago sativa	121° C.
M. luteus	112°	Avena sativa	118°
Papaver somniferum	100°	Hordeum distichum	118°
P. nudicaule	100°	Cucurbita pepo	112°
Meconopsis cambrica	100°	Helianthus annuus	112°
Schizopetalon walkeri	105°	Pisum sativum	112°
Brassica rapa	110°	Trigonella fenum-graecum	90°
Eschscholtzia californica	110°	Lotus tetragonolobus	100°
Lactuca sativa	114°	Convolvulus tricolor	120°
Helianthus argophyllus	110°	Nicotiana tabacum	112°
Lolium perenne	110°	Galtonia candicans	105°

Seeds of *Lagenaria vulgaris* and *Heracleum giganteum* were unable to germinate after exposure to a temperature of 90° C.

The seeds of any one species show considerable individual differences in their power of resisting high temperatures. Thus a large percentage of a sample of seeds, say of *Avena sativa*, will germinate after exposure to a temperature of 100° C.–105° C., while only a very small percentage will germinate if exposed to 118° C.

The time needed for germination is increased by exposure to temperatures near the maximum. In a general way the higher the temperature to which the seeds are exposed the longer will be the period of germination.

Long exposure to a comparatively low temperature may prove more fatal than a short exposure to a high temperature. Thus seeds which will germinate successfully after one hour's exposure to 110°–120° C. will not germinate after twelve days' exposure to a temperature of 95°–97° C.

6. *The Effect of Temperature on Carbon Dioxide Assimilation.*

By Miss Gabrielle L. C. Matthaei.

This investigation differs from any which have preceded it on the same subjec in the attention paid to uniformity in the environment of the leaves *before* the experiment. Recent work has shown that both the assimilation and the respiration of a leaf depend on its previous nutrition and temperature. For this reason a separate leaf was used for each temperature, care being taken to keep them for some time under exactly similar conditions.

Leaves of the Cherry Laurel (*Prunus laurocerasus*) were employed throughout.

Since allowance had to be made for the respiration, this was taken for each temperature under exactly similar conditions to those existing in the corresponding assimilation experiments. A good curve showing the gradual increase of the respiration with the temperature was obtained.

The lowest temperature at which assimilation could be detected was −6° C. This is the first well-established case of assimilation below 0° C.

For temperatures between −6° C. and 33° C. it was found that assimilation is affected in exactly the same way as is respiration. Provided the illumination is sufficient, the assimilation increases with the temperature. At any given temperature the leaf is only capable of a limited absolute amount of assimilation, and increase of illumination beyond the amount requisite for this maximal amount produces no further effect at all. A greater assimilation can only be obtained by increasing the temperature. Thus the fundamental condition regulating the assimilation is the temperature, the intensity of the light occupying a secondary position similar to that of the percentage of carbon dioxide. This simple conception of the relation between temperatures and assimilation stands quite apart from all previous views.

For temperatures above 33° C. the result is complicated by the injurious effects of the temperature. The fatal temperature for Cherry Laurel leaves is in the region of 41–45° C., but the specific resistance of the individual leaves is very variable. Death is shown by a rapid decrease in the respiration, but it may be several hours before this ceases entirely. Exposure to light has a most marked effect in increasing the resistance of leaves to the effect of high temperatures.

Most interesting results were obtained from the prolonged exposure of leaves to high temperatures. It was found that the respiration of a leaf in the dark falls off much more rapidly than that of a leaf in the light, and the former can in no case be taken as a measure of the latter. At first assimilation and respiration are equally and similarly affected by the temperature, but later the assimilation ceases, while respiration is still active.

7. *On the Dorsiventrality of the Podostemaceæ, with reference to current views on Evolution. By* JOHN C. WILLIS.

The paper read is an extract from a forthcoming paper in the annals of the Royal Botanic Gardens, Peradeniya, upon the Morphology and Ecology of the Podostemaceæ. This order shows a very far-reaching dorsiventrality of structure, both vegetative and floral. Two lines of argument are followed—one morphological, the other ecological. Commencing with the less modified types found in the order, which show a slight amount of dorsiventrality in the vegetative system and none in the floral, a series is traced through the more modified types, showing the progressive increase in dorsiventrality of the vegetative system followed throughout by an increase in that of the floral, showing first in the spathe and bracts, then in the androeceum, next in the gynaeceum, and lastly in the interior of the ovary. In the next place, the same series, regarded ecologically, shows that though the flowers are steadily more and more zygomorphic—a condition usually regarded as an adaptation to insect visits and accompanied by a horizontal position of the open flower—we have here flowers which stand stiffly erect, and are more and more anemophilous and autogamous.

The most reasonable explanation of these facts seems to be that the dorsiventrality of the flowers has been forced upon them, without reference to any advantage or disadvantage in the performance of their special functions, by the steadily increasing dorsiventrality of the vegetative system, the latter being due to the general effect of the total conditions of life acting on the hereditary peculiarities of the ancestral forms, whether directly or indirectly. Now the dorsiventrality of the floral organs is a character of high taxonomic value, and upon the various degrees of it the grouping of the Podostemaceæ is chiefly founded, while it is always regarded as important in other families. The conclusion drawn is supported by the facts of dorsiventrality in other families, and if admitted as probable opens up a number of new points of view, and raises questions which must be settled one way or the other.

If one character of importance may thus be forced upon an organ or organs without reference to any advantage to that organ in the performance of its functions, it seems only likely that others may; and consequently, that the study of adaptation must enter upon a new phase in connection with the study of comparative and experimental morphology and of variation.

Another question raised is the insecurity of our conceptions of genera and other taxonomic groups, and the need of some more quantitative and phylogenetic basis. We divide the Podostemaceæ, for example, into genera and sub-orders largely upon the degree of dorsiventrality displayed in the flowers and fruits, but we do not know the real quantitative or phylogenetic value of the distinctions. It also follows from the above conclusion that it is highly probable that many genera, species, sub-orders, or even larger groups, may be polyphyletic. We can easily imagine a group of allied or similar species, for example, all becoming more dorsiventral in their vegetative systems, and at last all of them showing the effect in the floral organs. As the effects in the latter seem to follow very definite rules, all these species may presently form a polyphyletic genus, there being no ancestor which has the generic characters. The same reasoning applies to higher groups, and in the very largest groups we are already beginning to perceive clearly that many, if not most, are more or less polyphyletic. It is evident that this view, if it prove true even in part, will help in clearing up the darkness which surrounds many of the problems of evolution, geographical distribution, &c.

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8. *Foliar Periodicity in Ceylon.* *By* Herbert Wright.

The high temperature and humidity of the air in most parts of Ceylon allow almost continuous growth of the arborescent vegetation. There are, however, nearly two hundred species which become leafless at different times of the year.

External and internal factors affect the phenomena of defoliation and foliar renewal. The climatic effect is obvious from the fact that the majority of our deciduous species become leafless during our hottest and driest months. The deciduous trees respond only to one hot dry period of three or four months, and not to the dry part of each monsoon. Some species undergo complete defoliation twice per year; others exhibit incremental foliar activity several times per year, in addition to a complete annual renewal, and many introduced species show great variation during their phase of acclimatisation. In the northern districts, where the rains of the south-west monsoon are very feeble as compared with those at Peradeniya, the defoliation is considerably delayed. The climatic conditions in Ceylon are not equable enough to allow continued development along personal lines, and botanists desiring to study the personal equation in plant life should select a more equable area.

Internal forces are, however, obviously at work, as evidenced by the following:—

(*a*) Species retain full possession of their foliage or put forth new leaves when the temperature and dryness of the air is at the maximum.

(*b*) Some species drop their leaves and remain bare during wet, cool months, when transpiration is at the minimum.

(*c*) Plants of the same species, on the same plots, are deciduous at periods varying by many weeks and months.

(*d*) The same species may undergo defoliation at approximately the same time of the year, though under the dissimilar climates of Peradeniya, Colombo, and Mannar.

The irregularity of foliar periodicity is very pronounced. There is not a month when all the trees are in full leaf.

The foliar periodicity of the evergreens is as complex as that of the deciduous trees, the foliar renewal taking place annually, bi-annually, or weekly, all being subject to individual variations.

Complete defoliation and foliar renewal in temperate and tropical zones often results in the differentiation of rings of growth in the secondary xylem. The variation in our tropical species is so great that an exact knowledge of foliar activity must be at hand before the time-value of the rings of growth can be determined. Saplings may undergo foliar repletion in the first year, or several years may elapse before this occurs; mature plants may be characterised by annual, bi-annual, or incremental periods of leaf production; further, many trees are repeatedly defoliated by the ravages of insects, bats, and fungi.

Foliar periodicity is the most potent factor in determining the number and significance of the rings of growth, but for the complete interpretation of these a further knowledge of the rate of cambial activity and the independent effect of a hot dry season is necessary.

The rate of cambial activity is of especial value in determining the varying significance of the xylem differentiations in slow-growing deciduous or quick-growing evergreen trees.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Papers were read:—

1. *Fossil* Nipa *Fruits from Belgium.*

By A. C. SEWARD, *M.A., F.R.S., and* E. N. ARBER, *M.A.*

2. *The Seed-like Fructification of Miadesmia Membranacea* (Bertrand), *a Lycopodiaceous Plant from the Coal Measures. By* MARGARET BENSON, *D.Sc.*

These interesting forms were first recognised in some Dulesgate slides sent by Mr. Lomax to Professor F. W. Oliver. Mr. Lomax has during the last year been able to secure many further examples which have confirmed Dr. Scott's suggestion that they were the missing sporophylls of Bertrand's new genus, Miadesmia.[1] The foliage leaf bears a ligule in a longitudinal groove with thickened base and sides. In the sporophylls the sporangia are inserted singly in the proximal end of the groove, and are large and pedicellate.

They lie in a plane parallel to the lamina. In the megasporophyll the sides of the groove are completely coherent above the sporange, and thus form a velum; while the fimbriated distal part, together with the lamina, form a micropyle and collecting apparatus. The wall of the megasporange is composed of several layers of isodiametric cells, and encloses a single thin-walled megaspore or embryo sac. The microsporange has no velum, and the wall is formed of a palisade layer. The author's thanks are due to Dr. Scott, who with Professor Oliver's sanction placed the earlier slides at her disposal.

3. *A possible Calymmatotheca Type of Fructification showing Structure.*

By MARGARET BENSON, *D.Sc.*

In some Dulesgate slides sent to the author in May 1902 there appeared some large sporangia, between 3 and 4 mm. in length and about 1 mm. in width, which are pointed at the apex and tapered somewhat to the base. The wall is composed of several layers of cells, and is provided with large tracheides.

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[1] Bertrand, '*Sur une nouvelle Centradesmide*,' Assoc. Franç. pour l'Avancem. de la Science, 1894.

In one of the slides these sporangia were coherent in a cluster of six to eight, and bore a very striking resemblance to the Calymmatotheca type, which has been so far only known in the form of impressions.

These sporangia are associated with petioles and other fragments of *Lyginodendron oldhamium.*

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4. *On some New Features in relation to* Lyginodendron oldhamium.

By J. LOMAX.

Since the year 1872, when the late Dr. W. C. Williamson published his Memoir, part iv., in the 'Trans. Roy. Soc.' on *Dictyoxylon*, *Lyginodendron* and *Heterangium*, this genus of fossil plants has undergone a good many alterations or modifications at the hands of the palæobotanist.

In the Memoir above quoted *Lyginodendron oldhamium* is described as an unbifurcating stem, but giving off very small branches (see p. 387, figs. 14 and 16, Pl. xxv. loc. cit.), and in some respects similar to a *Lepidodendroid* stem.

In his Memoir, part vi. 1874, he describes fully a stem to which he originally gave the name of *Edraxylon*, but which now appears under the name of *Rachiopteris aspera*. (See part vi., figs. 1 to 13, 'Phil. Trans. Roy. Soc.,' 1874. Fig. 13 he describes as a petiole with pinnules and leaflets.)

In Memoir, part vii. 1875, he describes a series of specimens under the name of *Kaloxylon Hookeri*. (See figs. 23 to 38, Pl. 5, 6, and 7, loc. cit.)

The small branches which Williamson described in 1872 under the name of '*Kaloxylon*' have since been proved to be the roots of *Lyginodendron*.

In the case of *Rachiopteris aspera*, it is now well known that it is the leaf-stalk or petiole of *Lyginodendron*, whilst the fossils known as *Sphenopteris Höninghausi* and *Sphenopteris distans* are the foliage of *Lyginodendron*. (See Williamson's Memoir, 1890, part xvii.; also Williamson's and Scott's Memoir, 1895, part iii.)

In most cases when this stem has been described it is as an unbifurcating or unbranching stem.

In Dr. D. H. Scott's 'Studies in Fossil Botany,' p. 321, he says that 'No stem has ever been observed to branch; it does not follow that it never did so, but branching must have been very rare.' For some time back I have had various specimens in my possession which I have collected from Dulesgate, near Todmorden, Lancashire, which to me have had the appearance of giving off a branch; but during the last few months I have discovered two specimens which have set all doubt on this point at rest. Both specimens are in a first-class state of preservation.

The first of the two specimens was collected in March last, and is now in the possession of Dr D. H. Scott; it shows a series of twenty-four sections cut transversely. The series runs through two internodes; the first shows the leaf-trace just about to leave the periderm, and the stele is commencing to take a crescent-like form on the opposite side to that of the leaf-stalk which is being given off, and so on till the stele of the branch and stem are completely separated, and till the second leaf-stalk is given off. There are also several roots given off, one or two of which dichotomise immediately after leaving the cortex.

In the above stem there are a series of four double leaf-trace bundles. The entire diameter of the stem is ¾ inch and about 3 inches long.

The last specimen I have discovered is also from Dulesgate, from a mass of small nodules, one part of which contained a quantity of foliage, broken pieces of *Sigillarian* bark, *Rachiopteris bibractensis*, and various other fragments.

In this there is a series of five leaf-trace bundles. This was about 1⅛ inch in diameter and about 4 inches long.

The stem is not quite whole; a portion of one side is missing, but the development of the branch is seen quite perfectly.

The above two specimens show that *Lyginodendron* had a branching stem; also that the branch was given off in the one case between two leaf-stalks and in close proximity to several roots. This shows that it has been a plant of considerable growth.

The position of the roots also shows they must have been aërial roots, and not, as generally accepted, basal or confined to the basal regions of the stem.

There is one other point we want to make clear, and that is the generative organs of the plant. So far they have escaped our notice, but I expect that we may before very long be in a position to state definitely what were the fructificative or the regenerative organs of these most interesting fossil plants.

The detailed description of the above specimen is left in the hands of Dr. D. H. Scott.

5. *Sporangiophores as a Clue to Affinities among Pteridophyta.*
By D. H. Scott, *M.A., Ph.D., F.R.S.*

Some years ago the writer suggested the probability of an homology between the ventral sporangiophores of *Sphenophyllum* or *Cheirostrobus* and the similarly placed synangia of the Psiloteæ; on this ground, among others, an affinity between the fossil and the recent family appeared tenable. This view has recently been supported by Professor Thomas of Auckland, N.Z., on evidence drawn from certain remarkable variations which he observed in the genus *Tmesipteris*. In the present communication the evidence from comparative structure in the typical forms is considered.

On the view suggested, the synangium of the Psiloteæ is neither a reduced strobilus nor a septate sporangium, but a ventral sporangiophore bearing a variable number of sporangia, normally two or three, according to the genus.

If this interpretation holds good, the nearest affinities of the Psiloteæ would be with the extinct Sphenophyllales rather than with the Lycopod phylum, though relationship no doubt exists in both directions.

In the Sphenophyllales and Psiloteæ the sporangium-bearing pedicel is to all appearance a ventral lobe of the sporophyll. Yet it presents, in certain cases, the closest agreement with the sporangiophore of the Equisetales, which as a rule appears to represent either the entire sporophyll or an independent outgrowth from the axis. *Palæostachya*, indeed, suggests a possible transition from the one type to the other, for here the sporangiophores are inserted immediately above the 'bracts,' almost as in *Cheirostrobus*. It is not necessary, however, to strive after a uniform interpretation in all cases. We may regard the sporangiophores either (1) As independent reproductive appendages, which may arise in various positions, or (2) as representing specialised leaves, or portions of leaves, as the case may be. For the latter interpretation analogies may be found among the Ferns.

6. *Notes on the Morphology of the Araucarieæ.*
By Sibille O. Ford.

The Araucarieæ include the two genera *Araucaria* and *Agathis*; they are characterised by the regularity of their branching and the persistence of their leaves. Small 'accessory' lateral branches may occur in the region of the lateral branches.

In mature leaves more than one vascular bundle is present with conspicuous transfusion tissue composed of large elements with bordered pits.

The apex of the stem shows no definite apical cell, but a somewhat irregular dermatogen. Well-marked annual rings may be found in the wood, and bordered pits are found on the tangential walls of the latest formed summer wood.

Owing to the persistence of the leaves, the leaf-traces are continued through the wood of the stem for some years. Markfeldt has shown that partial tearing of the leaf-trace occurs from about the third year onwards in the region of the stem cambium. In *Agathis robusta*, however, tearing may also occur simultaneously in other regions of the trace.

The roots are diarch or triarch, and secondary thickening ultimately results in the formation of a ring of xylem. In *Araucaria bidwillii* division of the vascular strand into two horseshoe-shaped masses was observed.

The seedlings of *Araucaria*, section Colymbea, are characterised by a much-swollen hypocotyl. Each of the two cotyledons receives about five vascular strands from the hypocotyl; in the leaves a single bundle alone passes out from the stem to each leaf.

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7. *On the Occurrence of the Nodular Concretions (Coal Balls) in the Lower Coal Measures. By* JAMES LOMAX.

During the last fourteen or fifteen years that I have worked amongst fossil coal-plants I have been struck with the diversity of ways in which the different genera and species of plants occur in the different calcified nodular masses which we find so plentiful in the several localities where they are found embedded in the coal.

At the meeting at Bradford in 1900 there was a joint discussion between the Geological and Botanical sections as to whether the plants which entered into the composition of the different coal seams grew *in situ* or not, and from that discussion I gathered that the opinions were evenly balanced. Consequently, from that time to the present I have taken a very great interest in observing the position in which the nodules are embedded in the coal seam. It is well known that there is only one seam of coal in which we find these nodular concretions, and to which different names are given in the different districts where it is worked. In the Yorkshire district it has the name of the Halifax Hard Bed; in Oldham, the Upper Foot Mine; Bacup, the Mountain and Union Mine; Todmorden, which includes Dulesgate, the Union Mine; Sheffield, the Gannister Mine; and so on. But, where it is found, in nearly all cases the roof contains similar concretions, with this exception—that the fossil remains contained therein are of marine origin, while those found in the coal underneath are always of vegetable origin. Sometimes, but not very often, we may find a stray stem in the nodular concretions from the roof, such as *Dadoxylon*, *Calamites*, *Lepidodendron harcourtii*; and the best specimen of *Rachiopteris grayii* that has ever been found in the English Coal Measures I discovered in one of these nodules from the roof.

It is not my intention to enter into the chemical composition of these concretions, only so far as to state that in most cases they consist of calcium carbonate and iron pyrites in varying proportions; and in a few places we find that there is a mixture of silica with the carbonate of lime. I have obtained from three localities portions of the seam with these concretions of various sizes embedded in the coal. Some of the pieces I have obtained have been over 2 feet long and 1 foot in diameter. I have cut these in various directions to show the plant tissues—how they ran, whether one nodule was coincident with its neighbour (that is, if the tissues in the one nodule ran on into the next), and if the tissues of one nodule ran parallel with those of a succeeding nodule either lower or higher in the seam. In that object I have been very successful, as the specimens will show.

During these investigations it has been gradually forced on me that, at least in this case, these plant remains have not grown on the spot where we now find them, and for the following reasons:—In one nodule out of a number which were joined together by the surrounding coal we have a portion of a transverse section of *Stigmaria*, about one-half the whole section; and in the nodule adjoining to the right there is no portion of this *Stigmaria* whatever, but a fragment of a longitudinal section of *Amyelon radicans* and *Stigmarian* rootlets. In the one to the right above it there is still no part of it, and in the one to the left we have no part of it either. It is so with the various masses I have examined. Some we have which have contained nothing but *Stigmarian* rootlets; their neighbours would contain *Lyginodendron*, *Rachiopteris bibractensis*, and so on, in short pieces; another, *Stigmarian* rootlets, with a short piece of *Lepidodendron fuliginosum*, which could not be seen from the outside of the nodule, but was totally enveloped by the rootlets; and so on.

If these plants had grown on the spot where we now find them, and been petrified, we should have certainly found, where we had an abundance of nodules, that these stems would have been continued from nodule to nodule; but that is not so. What we find is a quantity of fragments of short pieces of stems, &c., some with the cortex, some without, some split in fragments, and so on. The natural conclusion is that the various portions of plants have been carried into their present position after being broken in fragments, and before petrification, or they have been carried from a parent bed after petrification.

8. *The Morphology of Sporangial Integuments.*
By W. C. WORSDELL.

Angiosperms.

Theories on the nature of the integuments of the *ovule*:—

1. *Foliar-appendage* theory: The integuments are the foliar appendages of the nucellus, which is a stem structure. Supporters of this view: Alex. Braun, Aug. St. Hilaire, Schleiden, Payer, Schmitz.

2. *Sui generis* theory: The integuments are special protective outgrowths of the sporangium, this latter being an organ *sui generis*. Evidence for this view is afforded solely by facts of ontogeny: Strasburger, Goebel, Eichler.

3. *Foliolar* theory, chiefly elaborated by the last of the undermentioned authors. Based entirely on the evidence of the abnormal metamorphoses of the ovule; these are of a very constant character, subject to control of very definite laws; the two integuments tend to proliferate into a three-lobed marginal leaflet or segment of the carpel, of which the terminal lobe, bearing the nucellus (when present) on its upper surface, represents the inner, while the two lateral lobes represent the outer integument; this is the extreme proliferated form. Between this and the normal ovule *every intermediate transitional form has been observed*, the extent of proliferation depending on the stage of development of ovule at which the tendency thereto sets in. Cases where proliferated outer integument appears as a simple lamina bearing normal cup-shaped inner integument containing nucellus on its *lower* surface; this structure arises morphologically by fusion of the inner margins of the two lateral lobes of the leaflet in the extreme proliferated form across the face of the latter, the terminal lobe at the same time becoming inrolled. The whole structure and mutual relationship of the parts is well shown by means of certain abnormal forms of foliage-leaf in *Syringa*. Hence the ovular integuments are the morphological homologues of a three-lobed segment of the carpel. In the normal ovule the upper surface of the inner integument is directed inwards to the nucellus, this latter being morphologically an *emergence* from that surface, while the upper surface of the outer integument is directed outwards and away from the inner integument. This applies to all cases: Brongniart, Cramer, Warming, Čelakovský.

Gnetaceæ.

Gnetum has normally three envelopes surrounding the nucellus. Theories as to their nature:—

Some regard outer envelope as an ovary, others as a perianth, others again as a third integument. The view maintained here is that it is a perianth, as two integuments occur uniformly throughout Gymnosperms.

Ephedra and *Welwitschia* each possess two integuments. Theory as to the nature of outer integument in the former: perianth.

Coniferæ.

Views as to nature of the sporangial appurtenances:—

Baillon, Parlatore, Sperk, and others regarded the single envelope as the ovary; almost all other botanists agree as to its integumental nature. Seminiferous scale: Schleiden, Baillon, Strasburger, Masters, regard it as an *axial* structure; Sachs and Eichler as a *ligular placenta*; Delpino and Penzig as the *two lateral lobes of the bract*; R. Brown as a *carpel*; Van Tieghem as *the first and only leaf of an axillary bud*; Braun, Caspary, Von Mohl, Stenzel, Čelakovský, and several others as homologous with *the two first leaves (or their ovular representatives) of an axillary bud*. Čelakovský holds further that throughout Coniferæ the ovule has two integuments; in Abietineæ, Taxodineæ, Cupressineæ, Araucarieæ, the outer integument is normally proliferated as a seminiferous scale, this being the exact counterpart of certain stages in the proliferation of the ovule of angiosperms; in *Podocarpus*, *Cephalotaxus*, *Torreya*, and *Ginkgo* it is the outer fleshy coat of the seed; in *Taxus*, *Microcachrys*, *Dacrydium*, it is the fleshy aril.

Cycadaceæ.

Most authors regard ovule as possessing a single integument. Čelakovský considers it, along with *Cephalotaxus*, &c., as being *holochlamydeous*, i.e., having the two integuments intimately united, the outer fleshy and the inner woody.

Filicineæ.

Homosporous Leptosporangiates.

Čelakovský's view here maintained that *soriferous segment of pinnule*, bearing as a rule sporangia on its lower (dorsal) surface, is the homologue of the outer integument of the ovule in Angiosperms, and *indusium* that of inner integument. Evolutionary series can be traced beginning with:—(1) *Thyrsopteris* and *Hymenophyllaceæ* where indusium, enclosing sorus, is *terminal* to leaf-segment = most primitive type. (2) *Dicksonia*, *Cibotium*, *Davallia*, *Lygodium*: the indusium, along with sorus, is displaced on to lower surface by outgrowth of leaf-segment. (3) *Cystopteris*, *Cyathea*, &c.: sorus arises from earliest stage onward on lower surface. (4) *Polypodium*, *Pteris cretica*: indusium completely disappeared; all these conditions have their homologues in stages of the proliferated ovule.

Heterosporous Leptosporangiates.

In Salviniaceæ the fruit is equivalent to an ovule with one integument; indusium = inner integument, and leaf-lobe bearing sorus is probably homologous with outer integument. Striking resemblance between monangic sorus of *Azolla* and an ovule. In Marsiliaceæ fruit = compound fruit of Salviniaceæ. In *Pilularia* it is homologous with the pinnately 4-foliolate leaf of *Marsilia*; in *Marsilia* with a pinnately multifoliolate leaf. Outer wall of sporocarp is homologous with *upper* surface of outer integument of ovule; indusium, enclosing *many sori*, with inner integument of latter.

In most Filicineæ sorus is polyangic; in Schizæaceæ and *Azolla* it is monangic, as in most Phanerogams. In latter polysorous character occurs abnormally in *Hesperis* and normally in *Cupressus*, where outer integument bears on its dorsal surface several inner integuments containing nucelli.

Lycopodiaceæ.

Isoëtes: View of Čelakovský held that *velum* is equivalent to indusium of Ferns, and *ligule* to the soriferous leaf-segment of latter; hence sporangium along with these two organs = ovule with its two integuments.

Lepidocarpon: 'Integument' is probably equivalent to velum of Isoëtes, but better developed, and thus to inner integument of ovule. Ligule is regarded as really situated outside the 'integument,' the latter being open at the distal end.

In other genera either velum or both this and ligule have either quite aborted or never been developed, which is probably result of efficient protection of sporangia by peltate ends of sporophylls, as in *Lepidodendron* and *Spencerites*.

In Equisetaceæ peltate sporophylls afford necessary protection.

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9. *On Ancient and Modern Seeds.* *By* Professor F. W. Oliver, *D.Sc*

TUESDAY, SEPTEMBER 16.

The following Papers were read:—

1. *On the Morphology of the Seed and Seedling of* Torreya. *By* Professor F. W. Oliver, *D.Sc., and* Miss Edith Chick.

The seed of *Torreya* is remarkable among Gymnosperms in possessing a ruminated endosperm. This character, which suggested a comparison with Brongniart's seed *Pachytesta* of the French Permo-Carboniferous, led the authors to a full investigation into the morphology of the genus. This has been possible through the courtesy of the Marquess of Huntly, in whose pinetum at Orton Longueville an old tree of *Torreya myristica* regularly produces fertile seed. To his head gardener, Mr. A. Harding, the authors are indebted for a continuous supply of ovules and seeds in all stages of development.

The young ovules emerge from the bud at the end of May, and are at once pollinated. The pollen-tubes are produced without delay, and by September the archegonia are developed. Fertilisation is accomplished during this month, and simple stratified embryos are formed before the winter. Next spring the embryos continue their development, the seed grows enormously in length, and by the second autumn is ripe.

Whilst a full account of the development of the seed is postponed till a future occasion reasons are given for regarding the seed as retaining many of the primitive characters distinctive of palæozoic gymnospermous seeds, and an attempt is made to elucidate the structure of the seed of *Torreya* in terms of these.

The structure of the seedling, in which the cotyledons are hypogeal, shows a near agreement with that of *Ginkgo*, and, with other features of *Torreya*, tends to strengthen the links connecting the Taxaceæ with the Cycads and primitive Gymnosperms.

2. *The Nature of the Vascular System of the Stem in Certain Dicotyledonous Orders. By* W. C. Worsdell.

The object of the present thesis is to show, from anatomical data, that no hard and fast line exists between the two classes of dicotyledons and monocotyledons. The hollow vascular cylinder of the stem of a great number of dicotyledonous orders, if not of all, has been derived from a system of scattered bundles such as is characteristic of the stem of almost all monocotyledons. The flowering-stem and peduncle, as being those parts of the caulome which have undergone least modification owing to the necessities of adaptation to external conditions, exhibit, as a rule, most clearly the primitive structure which in the vegetative parts has become obscured. The axial organs of the seedling, owing to their limited diameter and the small number of leaf-traces concerned in the building-up of the vascular system, cannot as a rule possibly exhibit the primitive scattered arrangement of the bundles.

As the stem increased in height and became more woody, and the leaves smaller and more numerous, the scattered arrangement of bundles in the stem (chiefly a result of the latter being mainly built up of large leaf-bases from which great numbers of pluriseriate bundles entered the axis) gradually became modified into that of a hollow cylinder, which was necessary both to support the bending-strains from a tall stem and to facilitate the continuous centrifugal addition of new conducting-tissues by means of a secondary meristem. The stems of plants possessing scattered bundles support bending-strains by means of a sub-peripheral sclerotic band, and, in those cases where a secondary meristem is present, increase their conducting tissue by the continuous centrifugal formation of new scattered bundles accompanied by interfascicular tissue.

As far as the investigation has gone, the primitive scattered arrangement of bundles can be traced in the stem of about thirty dicotyledonous orders, and no doubt many more will reveal it.

Other characters very frequently accompanying the above feature in dicotyledonous stems are:—

(*a*) V-shaped xylem; (*b*) reticulate and circular phloem; (*c*) bundle often concentric, with central circular phloem, and when collateral often with irregular orientation; (*d*) few, large vessels in xylem; (*e*) bundle rounded or elliptic and enclosed in sclerotic sheath; (*f*) very small development of cambium; (*g*) largest bundles occur nearest centre of stem, the smallest nearest the periphery; (*h*) rudimentary character of many bundles, representing those members of the vanishing scattered system which are not destined to form part of the functional cylinder; (*i*) limit between cortex and cylinder marked by a sclerotic zone; (*j*) cortical system of bundles which are often concentric in structure; (*k*) trimerous character of some or all of the floral whorls; (*l*) several orders exhibit 5-merous single perianth-whorl in flowers which, as Čelakovský has shown, is derived from two trimerous whorls by conversion of lowermost perianth-member into a bract.

In some monocotyledons the scattered bundles have become very peripheral, and even reduced to a single series or row of bundles.

In some cases amongst dicotyledons where the scattered arrangement has vanished from the stem it can still be found in the less modified foliage-leaf, especially where the petiole is cylindric in contour or possesses a considerable diameter.

In view of the above facts the author cannot agree with those writers who maintain that the vascular structure of the seedling stem of dicotyledons generally proves it to be primitively tubular in character. The same will, for reasons above set forth, apply to the case of monocotyledons.

A series of slides accompanying this paper illustrates the main feature of the subject in the stems, &c., of plants belonging to many natural orders.

3. *The Composition of the Flora of the North-east of Ireland.*
By R. LLOYD PRAEGER.

The counties of Down and Antrim form the most easterly part of Ireland, and the portion which most nearly approaches to Scotland. Their combined area is 2,148 square miles, and their flora numbers 820 species of flowering plants and vascular cryptogams, Antrim yielding 778 species, Down 752; the total flora of Ireland being reckoned at 1,020 species, and the average number occurring in an Irish county, according to present knowledge, at between 630 and 640. Down is formed of slates and granites, Antrim mainly of basalts. Limestone is very sparingly represented, and while the number of calcifuge plants in the flora is large, the calcicole group is poorly represented. With regard to the types employed by Watson to show distribution in Great Britain, there is in the local flora an almost complete representation of British type plants. English type plants are rather poorly represented, and are more plentiful in the Antrim than in the Down flora. Scottish type plants reach in Antrim their maximum for Ireland; in Down they are somewhat fewer. Of Highland type species there is a fair representation as compared with other Irish counties of similar character; Antrim, though of less elevation, contains more alpine plants than Down. Germanic plants are extremely few in Ireland, being only thirteen in number; of these the district yields but four. In Atlantic type plants Down and Antrim are comparatively rich.

Turning to the types of distribution which the reader has recently proposed for the Irish flora, we find the district is naturally very poor in Central type plants, which are largely calcicole and marsh species; while Mumonian and Connacian species are practically absent. Marginal type plants, on the other hand, are very largely represented, while of Ultonian species Antrim is conspicuously the focus, Down being considerably poorer. Lagenian plants are only tolerably represented, their focus lying farther to the southward.

As regards rare plants in the flora, Lough Neagh is phytologically one of the most interesting spots, not only in the district, but in Ireland. Here *Calamagrostis stricta* var. *Hookeri* is endemic; *Tolypella nidifica* (if the determination be correct) has its only British station; *Carex buxbaumii* has its only other British station in Aberdeenshire; while *Spiranthes romanzoffiana* is, outside the Bann basin, in Europe found only in Co. Cork. The Antrim basalt plateau yields *Saxifraga hirculus*, *Orobanche rubra* (in plenty), *Equisetum trachyodon*; while the rarest plants of Down are *Elatine hydropiper* and *Zannichellia polycarpa*.

4. *The Nucleus of the Cyanophyceæ.* *By* HAROLD WAGER.

WEDNESDAY, SEPTEMBER 17.

The following Papers were read:—

1. *A Disease of the Gooseberry, with Notes on* Botrytis *and* Sclerotium.

By Miss ANNIE LORRAIN SMITH.

The disease attacks the hard stem of the bushes above and below the ground level. The inner bark is permeated and completely destroyed by the mycelium of a fungus. The outer bark cracks and splits, and sclerotia are formed on the outside or half embedded in the cortex. A *Polyactis* type of *Botrytis* with small spores was found growing on the wood laid bare by the peeling-off of the bark, and also on some of the sclerotia.

Culture experiments produced more *Botrytis*, and from one of the sclerotia there grew both the *Botrytis* and a *Peziza* form which proved to be identical with *Sclerotinia fuckeliana*, a disease of the vine, but which in the latter only attacks the tender parts of the plant.

Measurements and cultures were made of various forms of *Botrytis* and of *Monilia*, and the results compared. Compact clumps of mycelium are formed in them all, which vary in the different species, and may be incipient sclerotia.

Crystals of oxalate of lime were formed in the *Botrytis* cultures, in one case sufficient to form a white deposit at the base of the gelatine.

2. *On the Morphology of the Flowers in certain species of* Lonicera.

By E. A. NEWELL ARBER, *M.A.*, *F.G.S.*

The genus *Lonicera*, L., includes some hundred species, of which about seventy belong to the section *Xylosteum*. The inflorescence of members of this section is remarkable in that the gynœcea of a two-flowered dichasium are more or less completely united together, a character which is made use of as a point of systematic importance. The normal occurrence of *synanthy* of this particular type is comparatively rare, but it is also found among members of certain other orders, e.g., *Rubiaceæ*.

A study of the morphology of the flowers of species belonging to the Xylosteum group shows that the union of the gynœcea is not effected in the same way in all species. A series of intermediate stages can also be found leading up to such marked types as *Lonicera cœrulea*, L.

In *L. xylosteum*, L., and *L. alpigena*, L., the two inferior ovaries are united in one plane by *the union of their receptacular walls*. This union is very complete in the latter species, and probably represents the perfection of this type of adaptation.

Intermediate stages may be found in *L. nigra*, L., and other species, in which the same result—the coalescence of the two fruits—is attained in another way. Here the gynœcea are for the most part free from one another, but surrounded by an outer parenchymatous tissue, arising from the base. This tissue is more highly developed in some species than in others. In *L. cærulea*, L., and *L. iberica*, Bieb., the two gynœcea are completely inclosed, and united with this outer tissue in certain planes. The morphology of this tissue is shown by the intermediate stages to be the result of the *fusion of the bracteoles* of the two flowers.

The *biological significance* of the coalescence of the two ovaries of the cyme is probably to be sought in the fruit, where the union is usually more complete and marked than in the flowers, and gives rise in several species to a *false berry*. This would seem to be an *adaptation in favour of increased seed dispersal*, in that the seeds of two flowers, inclosed in what is superficially a single berry, are eaten by birds at one time.

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3. *Some Inquiry into the Physics of the Flow of Fluids in Plant Stems.*
By Professor R. J. Anderson, *M.D., F.L.S.*

It is evident that the actual area of the canalicular system may vary from place to place, and *area* is a very important fact to take into consideration. The nature of the fluid is of great importance, for a fluid which is nutrient and natural is operated on by the tissues, and whilst its adhesive properties are considerably modified by the vitality of the tissues its physical characters are likely to be changed from end to end of the stem. Osmoses, too, which are ever constant, may change the flow in time. So also may the elasticity of the wood alter, and the resilience, extensibility, porosity, and amount of gases contained may all change. The formation of cork very soon affects the living exposed tissue, and the tissue is rendered impermeable.

The higher temperatures are more favourable to the flow than the lower. In living tissues the ebb and flow associated with chemical interchange is very apt to complicate cases, and what may appear a vital phenomenon may be a physico-vital or a purely physical one. The effect of 'the organic' in tissues not necessarily living seems to be a very important question. The 'organisation' leads to physical aberrations which, although not unknown, are rarely met with in so striking a manner in organic substances. One may place in this category the absorption of fluids and rise of temperature in some organic substances, and the restoration to the *status quo* on drying. Examples of physical movements and phenomena might be multiplied, but they are well enough known.

Stems of plants were experimented upon by various fluids of various degrees of concentration. The force was secured by a waterhead which acted directly or indirectly on the stems in question. The principal heights chosen were 9 feet, 4 feet, 3 feet 4 inches, and 1 foot 10 inches. The fluids used were water from the house main, distilled water, acidulated water, and water with various substances in solution. The solutions were sometimes very strong and at other times moderately weak. It may be well to note how far in these cases the results bore out Poisseuille's laws.[1]

(1) The greater the force the greater the flow. This seemed to hold generally, but with some odd aberrations not easily explained.

(2) The thicker the stem the greater (by far) the amount of fluid passed through.

(3) The longer the stem the greater the resistance.

(4) The higher the temperature the greater the flow, with some modifications and limits.

The first and most striking fact in connection with the experiments was the comparative ease with which almost all the fluids used passed through the stems with some few exceptions.

(2) The flow at night was generally lower than the preceding day, estimating the hours, and somewhat lower than a few of the midday hours of the succeeding

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[1] A waterhead of 17 feet and 22 feet as well as higher pressures were tested.

day (to the night). When the night was manifestly cold the flow seemed to be affected thereby.

(3) The flow in all cases did not reach its maximum at once, but the maximum once reached the flow gradually began to diminish, and hour by hour was often seen to diminish; but taking two, three, or four hours the change was most marked. So that after a few days the flow materially diminished in all cases.

(4) The flow experienced slight periods of increase and decrease. Thus after estimating the flow from 6 P.M. to 9 A.M. and reducing to the hour, the flow from 11 to 1 o'clock was found greater per hour.

(5) The flow having diminished considerably, it was found possible to restore in a measure the permeability of the stem by cutting ¼ inch or ½ inch from the upper end.

(6) The permeability although restored was not found to be as permanent as the first. The flow in most cases quickly diminished.

(7) After a series of amputations with the object of restoring the flow, the stem refused in several cases to transmit the fluids.

(8) The stems were weighed before and after the experiments in a few cases. The weight after was equal to the weight before the experiments.

(9) The change from a weak acid to a weak alkaline solution was not followed by an increase in the flow. It was noticed that a weak alkaline fluid did not appear as weak alkaline for a considerable time, and so far as an acid was concerned the same result followed.

(10) An increase in the specific gravity was followed in one case by an increase in the flow.

(11) The use of small stems was not attended with satisfactory results, as was the examination of larger stems.

4. *The Function of the Nucleolus. By* HAROLD WAGER, *F.L.S.*

5. Samsu, *a Fermented Drink of Eastern Asia, and its Characteristic Fungus. By* B. T. P. BARKER.

Samsu is a variety of arrack. It is obtained by the distillation of a fermented liquor prepared from rice. Rice is boiled in water and, after cooling, a powdered substance is added to the mixture. This substance causes fermentation, at the end of which the liquid is distilled. The distillate is subjected to a second and third distillation, the final product constituting the true *Samsu* and containing a high percentage of alcohol.

The powdered substance can be obtained in the form of small round greyish cakes. One of these was obtained by Mr. D. T. Gwynne-Vaughan at Singgora during the Skeat Expedition to the Malay Peninsula. The author is much indebted to him and to Mr. R. H. Yapp for the supply and for information concerning the manufacture of the spirit.

The composition of the cake is a trade secret, but there are apparently several ingredients, of which pepper and fruit of some kind form a part. On adding a portion to boiled sterilised rice a fungoid growth soon appears, and a red or purple coloration is produced. This is due to a species of *Monascus*. A bacterium capable of fermenting glucose has also been isolated.

The biological processes concerned in the manufacture of the spirit are the conversion of the starch of the rice into fermentable sugars by fungi, in particular by a species of *Monascus*, and the alcoholic fermentation of these sugars by a bacterium, and possibly also by wild yeasts. The species of *Monascus* is of especial interest. Hitherto the genus has been placed in the Hemiasci on account of a supposed formation of spores in a sporangium, surrounded by an investment of hyphæ. It is, however, a true Ascomycete. The fructification is formed from an archicarp, consisting of an antheridium and ascogonium, between which fusion takes place. From the latter a 'central cell' is cut off, which swells considerably, becomes invested by hyphæ, and produces ascogenous hyphæ. Owing to the nature of the developing ascocarp, the much-enlarged central cell assumes a shape so that it completely surrounds the ascogenous hyphæ, which soon produce small spherical eight-spored asci. The spores quickly ripen, and are set free in the cavity, formed by the curiously shaped central cell, by the degeneration of the asci and ascogenous branches. Thus a sporangium-like fructification is produced.

Monascus must hence be regarded as one of the simplest sexual Ascomycetes.

A fuller account of the species, with figures, will be published later.

6. *The Darnel Seed-fungus. By* E. M. FREEMAN.

7. *Sex in Ceylon Species of* Diospyros. *By* HERBERT WRIGHT.

The genus *Diospyros*, throughout the world, and particularly the species found in Ceylon, have hitherto been regarded as mainly diœcious.

In Ceylon there are twenty species of this genus, and by an examination of fresh material in the forest the following sex relationships have been determined:—

1. *Diœcious only.*—Here the male and female flowers are on different trees. Examples, *D. quæsita*, Thw.

2. *Monœcious only.*—The female flowers are in the axil of young leaves only, or terminate the young shoot; the male flowers form sessile clusters on woody twigs or in the axils of old leaves. Examples, *D. acuta*, Thw.; *D. oppositifolia*, Thw.

3. *Diœcious and polygamous.*—In this group there are: (*a*) true male trees, (*b*) true female trees, (*c*) trees with male and hermaphrodite flowers. Examples, *D. gardneri*, Thw.; *D. affinis*, Thw.; *D. sylvatica*, Roxb.; *D. embryopteris*, Pers.

4. *Diœcious, Monœcious, and Polygamous.*—In this, the most complicated group, there are (*a*) true male trees, (*b*) true female trees, (*c*) trees possessing true male and female flowers on the same twig, (*d*) trees possessing male and hermaphrodite flowers. Examples, *D. hirsuta*, L.; *D. thwaitesii*, Bedd.; *D. ebenum*, Koen.

Continued observations on the flowers, outside the herbarium, will probably reveal more departures from the diœcious condition, previously considered the normal.

8. Weisia rostellata, *Lindb., in Ireland. By* J. H. DAVIES

Since the Association last met in Belfast the Irish list of mosses has been enriched by the addition of several species. Two of them, *Cinclidotus riparius* and *Ditrichum vaginans*, were mentioned as being new to the British moss-flora. *Weisia rostellata*, not previously known to occur in Ireland, has been detected very recently in Co. Antrim. The finding of this and other unexpected plants in the north of Ireland leads us to hope that further investigation may reveal yet other rarities.

9. *Two Varieties of* Trifolium pratense perenne. *By* W. WILSON.

Section L.—EDUCATIONAL SCIENCE.

President of the Section—Professor Henry E. Armstrong, LL.D., Ph.D., V.P.R.S.

THURSDAY, SEPTEMBER 11.

The President delivered the following Address:—

I am sure all will be in agreement with me when, at the very commencement of my Address, I refer to the grievous loss we have suffered through the death of Mr. Griffith. Many of us could count him as our good friend, and are aware that he displayed a fulness of sympathy altogether rare among officials towards all members of the Association. The value of the service he rendered to the Association, on account of the breadth and accuracy of the stores of knowledge at his disposal, although widely felt and recognised, was so veiled by his modesty of manner and the quiet regularity with which he did his work that only the few who came intimately into contact with him can rate his doings at their proper worth. The smoothness with which the proceedings of the Association were carried on from year to year, notwithstanding the great variety of interests represented in it, was in no small measure due to his diplomacy. I have had special opportunities of appreciating his extraordinary versatility, as it has been my good fortune during recent years to come much into contact with him in connection with the Royal Society's Catalogue of Scientific Papers—a work to which he unsparingly devoted himself, rendering thereby important service to science. To no Section of this Association can his death be a greater loss than it is to ours. The foundation of the Section was in large measure due to his sympathetic encouragement and support, and he looked forward to the time when it would be one of the most important and popular in the Association. He thought of it, I know, as the one which was likely to bring about a fuller understanding of the value of science to the community, and eventually to knit a close relationship between the scientific fraternity and the general public. The withdrawal of his counsel has been to me an irreparable loss, and in judging of my shortcomings I trust you will bear in mind that at the critical moment I have been unable to appeal to his balanced judgment for advice.

The last meeting of the British Association at Belfast was presided over by Professor Tyndall, one of whose most memorable discourses was that delivered at Liverpool in 1870 on 'The Scientific Use of the Imagination.' In the course of his Address the President could point out that 'science had already to some extent leavened the world': abundant proof has since been given that he was right in claiming that 'it will leaven it more and more.' Nevertheless, if we consider the leavening effect which science has had on the public mind, it is impossible to deny that progress is being made in this direction at a woefully slow rate, in no way proportionate to the growth of knowledge or to the recognised usefulness of the many discoveries which are the outcome of scientific investigation. Science is still treated by society as a rich *parvenu* all the world over, and is at most invited to its feasts but not incorporated, as it should be, with the domestic life of the people.

Complaint has long been rife that the British are indifferent as a people even to things of manifest importance which as a nation of business men they might be expected to value. It would certainly seem that we are all too forgetful of Tyndall's warning that 'every system which would escape the fate of an organism too rigid to adjust itself to its environment, must be plastic to the extent that the growth of knowledge demands.' As our President said a full quarter of a century ago, 'when this truth has been thoroughly taken in, rigidity will be relaxed, things not deemed essential will be dropped and elements now rejected will be assimilated. The lifting of the life is the essential point, and as long as dogmatism, fanaticism and intolerance are kept out, various modes of leverage may be employed to raise life to a higher level.'

But how are we to become plastic to the extent that the growth of knowledge demands, in order that rigidity may be relaxed, that conservatism may give way to a wise spirit of advance? Probably there is no more important question the nation can ask at the present time: for that we are wanting in plasticity is proved to demonstration. Does not the shade of our former President stand before us and solemnly give answer: 'By the cultivation and exercise of imaginative power—by the scientific use of the imagination'; for in these days are we not indeed a people 'of little faith'? There would seem, in fact, to be clear evidence, if not of destruction, at least of impairment, of imaginative power under modern conditions—that the tendency of education is to kill rather than to develop the very power on which the progress of the world depends. A dearth of imaginative power is strikingly apparent in art, in literature, in music, in science, in public taste generally, the prevailing tendency being to imitate rather than to originate and individualise. Commentators and critics of sorts abound, but these rarely display any catholicity of judgment. Leaders are few and far to seek. The prevailing policy is that of the party in power—and more often than not of a caucus behind it—not the policy which on broad general grounds is the most desirable; in fact, little attempt is made to discover in any scientific manner what would be the really wise policy to pursue. Nothing could illustrate this better than the state of chaos into which affairs educational are plunged at the present time. Those who dare to differ or offer advice are looked at askance and always with jealous eyes; too often also everything is done to block the way of the reformer, not from any base motive but as a rule from sheer inability to appreciate what is proposed—from sheer lack of imaginative power. Necessarily, as the conditions of civilisation become more complex, the tendency to accept and follow must become greater, self-satisfaction more and more complete and general: unless effective means be taken to counteract such a tendency, decay is inevitable.

The phrase 'creatures of habit' is familiar to us all: few will deny that we are seldom otherwise than creatures of habit, that plasticity of mind is a rare attribute. But the growth of knowledge is taking place at such a compound interest rate that a high degree of plasticity is essential if we are to avail ourselves thereof. We were formerly accounted a nation of shopkeepers—of clever shopkeepers—but now the title is passing from us to the Germans and Americans, because they are more alive than we are to the fact that in these days it is necessary both to organise and to be alive to every opportunity. If we would put money in our purse in future, it will be necessary to put imagination into our affairs, so that we may be far more ready to act than we have been of late years.

And not only is knowledge increasing but our responsibilities are daily becoming heavier and heavier. In the minds of thinking men at the present time the burden of empire our nation bears is of appalling magnitude: the men who have imaginative power are aghast at the flippant unconsciousness of responsibility manifest in the public at large and even in the majority of our statesmen and politicians. It is widely felt that a deeper sense of responsibility must be induced among us, if we are to maintain our heritage intact—if we are to remain worthy to play the great part for which by an inscrutable ordinance we find ourselves cast at the very commencement of a new century. Nothing is so sure as that if we cannot show ourselves to be worthy we shall not long be allowed to play the part: jealousy confronts us on all sides; and we have learnt that the struggle for existence is Nature's first law, against which philanthropy is powerless so long as it be not universal—a contingency which is not even remotely possible. It is little short of remarkable that we should be able to go so far as we do in securing the services of able men to conduct our affairs generally; but we cannot be too mindful of the duty incumbent upon us of developing the store of ability latent in the nation and above all of maintaining intact our heritage of individuality.

The call to organise the forces of our empire is imperative but we do not heed it in any proper manner. For many years past we have rarely refused to treat with utmost consideration the representations of those who have dwelt on the importance of our Navy. One of the most highly respected men in the country at the present day is our gifted American cousin, Captain Mahan, on account of the way in which he has exercised his powers of imaginative insight and taught us to understand our achievements at sea, to appreciate the true meaning and value of sea power. We need a Mahan to discuss the larger issues of national defence through education, to teach the nation the true meaning and value of education. The Ship of State is of vastly greater consequence than the mere Navy: yet those who direct attention to the insufficient character of its armament are scarce listened to; not the slightest effort is made to secure for it a scientifically adjusted and organically complete machinery for the effective administration and working of all its departments; the drill of its crew is woefully incomplete; what is worse, there is a terrible absence of organisation and discipline, a terrible absence of willingness, little if any desire to co-operate among those who are charged with its care; and the consequences of neglect are not immediately obvious. In war we appreciate the effects suddenly: a long list of killed and wounded brings its meaning home to us at once; we know that we must pay the penalty of defeat forthwith; the indemnity exacted can be expressed as a lump sum. The battle of life is waged in a less obtrusive way, the killed and maimed are not scheduled in any regular manner, and so it escapes our notice that in reality the carnage is awful, that few if any escape without severe wounds, that defeat is constant and yet often dealt so silently and imperceptibly that it excites little comment. But we know that vastly more than is done might be done to alleviate if not to prevent suffering and even to give charm to life where at present there is but pain, if only our efforts could be organised. If we reflect on the bareness of the life lived by the majority, on the debasing conditions under which very many are placed, on the terrible evils consequent on indulgence in drink—surely we must agree with Tyndall that the essential point is to raise life to a higher level, to elevate the general tone of thought, and that it is our duty to consider more seriously than we have done hitherto what use can be made of the forces at our disposal for the purpose.

If we will but picture to ourselves how most of our difficulties, and especially our slow advance are consequences of lack of imaginative power, or perhaps rather of failure to exert the power which, though latent in most of us, is not sufficiently called into being by practice; if we will but consider how much of our success has been due to the exercise of imaginative power: we may be led to propound a fruitful theory of education, a theoretical basis on which a sound educational structure may be reared. It has been well said by Carlyle 'that all that man does and brings to pass is the vesture of a thought.' In fact, the illustrations which may be given of the value of theoretical conceptions, of imaginative power, are innumerable. Taking recent events, if we consider the success achieved by the late Mr. Rhodes, the narrow-sighted will say he was a practical man: a man who did things and led others to do. Those with broader views recognise that at heart Mr. Rhodes was a theorist, an idealist, a man of imagination—hence his success. And men such as Lord Roberts and Lord Kitchener, whose immense services to the nation have been so universally admitted of late, are not merely practical soldiers of experience but men gifted with powers of insight and imagination—men able to apply theory to practice. Some of those who were nsuccessful in the late campaign are currently reported to have gone out to South Africa openly deriding science: it will be well if the lesson taught by heir failure be not disregarded by their colleagues. The importance of the part layed by theory in science cannot be exaggerated. We have only to think of he influence exercised by the Newtonian theory of Gravitation, by the Daltonian heory of Atoms, by Faraday's conception of Lines of Force, by the Wave theory in ts varied applications, by the Darwinian theory of Evolution; we have only to hink of the way in which the reflections of one weak man indited at his studyable in a secluded Kentish village have changed the tone of thought of the ivilised world. Such theories are the very foundations of science: whilst facts re the building stones, theories furnish the design, and it is the interpretation of acts in the light of theory—the considered application of theory to practice—hat constitute true science. The marvellous development of scientific activity luring the past century has been consequent on the establishment of fruitful heories. If teachers generally would pay more attention to theory, their teaching vould doubtless be more fruitful of results: facts they know in plenty but they ack training in the considered use of facts. False prophets among us have long aught the narrow doctrine that practice is superior to theory, and we pretend to elieve in it. That the belief is founded on misconception may safely be contended, owever: the two go together and are inseparable. It is true that we have njoyed the reputation of being a practical people, and have been accustomed to ake no little pride in the circumstances, to scoff somewhat at theory: but ehind our practice in the past there was a large measure of imaginative power, f theoretical insight; in fact, we were successful because we were innately ossessed of considerable power of overseeing difficulties, of grasping an issue, of rushing aside unessential details and going straight to the point: in other words, f being practical. We are ceasing to be practical because modern practice is ased on a larger measure of theory and our schools are paying no proper ttention to the development of imaginative power or to giving training in the se of theory as the interpreter of facts: didactic and dogmatic teaching are producing the result which infallibly follows in their wake: sterility of intellect.

Mr. Francis Darwin, in his Reminiscences of his father, tells us that 'he often aid that no one could be a good observer unless he was an active theoriser.' And e goes on to say: 'This brings me back to what I said about his instinct for rresting exceptions: it was as though he were charged with theorising power ready o flow into any channel on the slightest disturbance, so that no fact, however mall, could avoid releasing a stream of theory, *and thus the fact became magnified nto importance.* In this way it naturally happened that many untenable theories ccurred to him; but fortunately his richness of imagination was equalled by his ower of judging and condensing the thoughts that occurred to him. He was ust to his theories and did not condemn them unheard; and so it happened that e was willing to test what would seem to most people not at all worth testing.'

In his Autobiography Darwin remarks:—'I have steadily endeavoured to eep my mind free so as to give up any hypothesis, however much beloved (*and I annot resist forming one on every subject*), as soon as facts are shown to be opposed o it.' The italics in these passages are mine.

Our system of education has no proper theoretical basis. Educators have eased to be practical because they have failed to keep pace with the march of iscovery, the theoretical basis underlying their profession having been enlarged o rapidly and to such an extent that it is beyond their power to grasp its roblems. The priesthood of the craft are, in fact, possessed by the spirit of arrow parochialism: they are upholders of an all too rigid creed, being lineal escendants of a privileged class—'the knowledge caste,' to use Thring's expression—whose functions were far more limited than are those which must now be lischarged by teachers if teaching is to be given which will serve as an efficient reparation for life under modern conditions. They enlarge *ad nauseam* on the uperiority of literary and especially of classical training, forgetting that their reference for classics is but the survival of a practice and that their arguments in lefence of a literary system are but preconceived opinions. Being incapable of appreciating the arguments used on the other side, it is unlikely that they will ever be able to admit their force.

So long as the forces of Nature were not tamed to the service of man, they could be neglected: sanitary sins were alone found out and punished with unsparing severity. But now it is otherwise. To succeed in competition with others we must be able to avail ourselves of every opportunity; and wide understanding is demanded of us. Moreover the growth of knowledge has induced severe mental hunger; the feeling that the dainty dishes provided by Nature should be in no selfish manner restricted to the few is a growing one; altruism is a growing force. We feel that we are called upon to counteract the evils arising from the growth of our cities; from the concentration of workers in large bodies; from the minute subdivision of labour; from the depressing conditions under which the masses daily toil. To provide relief and healthy occupation for leisure hours, to secure that vacuity of mind and pettiness of motive shall no longer be the sore affliction they now are, we must take all the requirements into consideration and define with utmost minuteness the task in hand; broader and higher ideals than those now prevailing must be established, practical requirements must be met. To secure the right attitude of mind for this task will not be easy. Few realise, few know, how signal is our failure to appreciate our power, how deplorably we neglect our opportunities. The bareness of the fare we provide is nothing less than shameful in view of the rich possibilities which lie ready to hand. In saying that

A primrose by a river's brim,
A yellow primrose was to him
And it was nothing more,

the poet has well pictured our average attitude towards our surroundings. To the majority indeed a primrose is scarcely a primrose; it is unseen. It is little short of impossible to account for our callous disregard of the wondrous beauty of the multitudinous objects displayed in Nature's realm, our willingness to remain ignorant of the meaning of the mysterious changes which are ever happening before our eyes. That familiarity should breed such contempt is passing strange; but how great the guilt in these days of those who allow the contempt to grow up, knowing as they must that the ignorance is easy to dispel, knowing also that those versed in the mysteries have ever sought to lay bare all that is within their ken. The failure on the part of those who have the charge of education to make a scientific use of the imagination is nothing short of complete; there is nothing to show that the imagination is ever called into play.

Surely it were time to make some real effort to imbue all with a proper understanding of their surroundings, to create in all minds a higher and reverent interest in life.

It is a sad reflection and a grievous blot on our civilisation that our spiritual advisers are mostly so little regardful, so destitute of understanding, of the works of that Omnipotent Power which all must recognise and humbly submit to whether or no allegiance be acknowledged in doctrinal terms: they before all others should be prepared to consider their inmost meaning and to direct attention to their wondrous mechanism. We indeed need to send forth a new mission charged with the holy duty of enabling man to appreciate and acknowledge the beauty of the universe as well as of preparing him to be a thoroughly effective worker, thus fitting him for the true, unselfish and reverent enjoyment of life. To use the apt words of the Master, quoted by the Poet at the Breakfast-table: 'if for the Fall of man, science comes to substitute the Rise of man, it means the utter disintegration of all the spiritual pessimisms which have been like a spasm in the heart and a cramp in the intellect of men for so many centuries.'

If we can but make sweet use of our present adversity, though we may not be exempt from public haunt but live even in crowded cities, we shall unquestionably soon find

. . . tongues in trees, books in the babbling brooks
Sermons in stones and *good in every thing.*

The wonderful prescience of our great poet is nowhere more clearly displayed than in these lines; it is more than surprising that although generations have been charmed by the music of the words so little has been done to realise their meaning or to give them a meaning in the minds of the majority.

It is but a question of attitude, for as Carlyle somewhere says, 'so soon as men get to discern the importance of a thing they do infallibly set about arranging it, facilitating it, forwarding it and rest not till in some approximate degree they have accomplished that.'

Unfortunately, there are all too many things of which we fail, through our faulty education, to discern the importance but which a little understanding, the exercise of some slight imaginative power, would enable us to appreciate. I will take the word *Energy* as an example. No word in the English language carries more meaning to those versed in the principles of physical science: yet how narrow is its connotation in the minds of the uninstructed majority. As a guide of practical conduct, no word is of greater significance; if its true implication fully seized us the word would ever rankle in our ears and serve to remind us of the maxin 'Waste not, want not.' In Great Britain we are using up our coal stores at the rate of over two hundred millions of tons per annum. Used at such a rate, the supply cannot last many generations; whence will our children derive their supplies of energy? Energy cannot be created. When we have squandered the wealth funded on our earth by the sun in æons past, we must fall back on the modicum we can snatch from the daily allowance the glowing orb dispenses, for his largess will for the most part be wasted and will be very difficult to garner in our country: sun mills, wind mills and falling water being but irregular and ill-disciplined servants, trees growing but slowly. In all civilised countries the same criminal waste of fuel—of energy—is going on; but although we recognise that individual men have no right to live beyond their means and have little pity for bankrupts, no corresponding feeling exists on the subject of collective squandering. The spendthrift is regarded with equanimity, because he but distributes his gold among the many—so that the many gain while he alone is the loser, but the energy of fuel is spent irrecoverably and all waste is not merely apparent but real. To waste fuel is to court criminal bankruptcy; but to how many does it occur that we are all parties to such a crime? Does any schoolmaster or schoolmistress call attention to the fact? How many heads of schools could even write a respectable essay on such a topic? When I have suggested 'A piece of coal' as the subject for a scholarship examination essay, I have actually been told by literary critics that you have no right to ask for knowledge of facts in a schoolboy's essay, the object being but to find out to what extent he can 'gas' in flowing periods! A scuttle full of coal excites no emotions in the literary mind; it should be one to call up harrowing visions, as well as a vista of memories extending far back into the ages of time—for in no other stone can we find a more wonderful sermon.

To descend to the ordinary level, how many householders ever take into consideration the wicked waste of fuel which goes on in their establishments? how many are really thrifty in the use of fuel? I never see a 'Kitchener,' or hear it roar, but I shudder. The prevention of smoke is of no consequence in comparison with the prevention of the waste of fuel. Even when every care is taken the waste is very great—simply because our means of utilising the energy of fuel are so imperfect. The best steam engine can recover for us but very few per cent. of the energy stored up in the coal which is burnt in its boiler fire. If we could succeed in burning fuel electrically—in directly converting the latent energy into electricity—it is conceivable that the engine might be of nearly theoretical efficiency. But what imaginative power must be exercised to secure such a result! Cannot we in some measure hasten the time of such discovery? Professor Perry not long ago had the temerity to direct attention anew to the subject in 'Nature,' and made what many practical people will consider the impossible suggestion of a wildly imaginative, irresponsible Irishman: that a round million or so should be devoted to systematic experiments, with the object of discovering means of increasing the efficiency of our engines. If we consider what is the cost of a modern battleship; if we consider what has been spent on the war in South Africa; if we consider the extent to which the value of the fuel at our disposal would be increased if we could only double the efficiency of our engines and of our stoves, Professor Perry's proposal cannot be regarded as otherwise than modest and sensible. But what is of real importance is the implied suggestion that the subject should be seriously inquired into at national expense. It must, and at no distant date, be admitted that our fuel stores are national assets over which there should be some national control.

I may take Food as another subject of which we fail to discern the importance, and which is outside the schoolmaster's ken, although teachers have stomachs as well as other men and boys in particular are believed to take some interest in the existence of that organ. It is but a variant on that of energy, as the food we take is mainly of value as the source of the energy we expend—as fuel, comparatively little being required for the construction and repair of the bodily machinery.

> . . . God has made
> This world a strife of atoms and of spheres;
> With every breath I sigh myself away
> And take my tribute from the wandering wind
> To fan the flame of life's consuming fire.
> *Oliver Wendell Holmes.*

How many will appreciate this pregnant passage? In how many schools is instruction given which would make it possible to recognise its beauty and completeness as a statement of the philosophy of the respiratory process? Our ignorance of ourselves and of the functions of food is indeed phenomenal. Life involves the unceasing occurrence of a series of changes for the most part chemical. If the proper study of man be man—as the highest dignitary of our Church some time ago asserted it was—the ordinary person would be prone to assume that those in charge of education would so direct studies as to give man some interest in his own wonderful mechanism; instead they almost uniformly direct that true 'culture' consists in knowing what he has thought and written of himself in classic tongues in ages gone by before the slightest vestige of understanding of the phenomena of life had been obtained. And we moderns calmly suffer this, and at the same time wonder at the way in which primitive peoples allow their medicine men and wizards to dominate them. Taking into account what is known, ours perhaps is relatively a deeper savagery than is that of most untutored races: our educational priesthood are for the most part never trained to a knowledge of the mysteries and deny admission through ignorance rather than wilfully.

From food to the preparation of food is an easy step—in point of fact the knowledge how to prepare food properly is of far more importance than any knowledge of what food is and does, as on it depends much of the happiness and health of mankind. Cooking is a branch of applied chemistry. We live in a scientific age—an age of knowingness. We might therefore expect that our girls at least would be so trained at school that with little effort they could become knowing cooks. I am not aware that the authorities who lay down the regulations for University Locals or similar examinations have allowed any such vulgar considerations to guide them in drafting their examination schemes: niceties of grammatical construction, recondite problems in Geography and History, the views of an ancient philosopher who gave himself up to angle worship, are alone thought of on such occasions; and yet there are times, it is said, when these august persons deign to take some notice of culinary efforts: they cannot be unaware that cookery is a subject of some importance, which might well at least be led up to at school. To justify my reference to the subject, let me read a passage from 'An Address on Education,' delivered, not by a narrow-minded Goth who is so lost to reason as to doubt the sufficiency of an exclusively literary training as a preparation for life, but by a classic, the Headmaster of a great public school, Thring of Uppingham, in speaking of the Higher Education of Women at St. Albans in 1886.

'We English are proud of our homes. We sing songs about them, we write on them; in fact, we are very justly *proud of our homes.* Has it ever entered your minds that home to the great majority in a very large degree, and to all in some degree, is but a loftier name for cookery? In a cottage good cookery means economy, luxury, health, comfort, love. . . . Cookery to the vast majority of mankind means home, and when the weary worker comes back from work wanting to refit, cookery alone can turn him out fit for work again. From this point of view home is cookery.'

Cookery is certainly a subject of which those in charge of education have not yet in any way discerned the importance. Our cooks are inferior and wasteful simply because they fail to exercise sufficient imaginative power. If we wish to make good cooks of our girls, we must teach them to think for themselves and to be imaginative—to make a scientific use of their imagination; they will then come to see that the subject is a vastly interesting one, full of opportunity for research. The kitchen, of all places, is the one, in fact, in which the heuristic method should most flourish.

Could we find tongues in trees we should doubtless find them eloquent on the subject of food supply and far more delicate in their tastes than any mortals. But how many of us, looking at a green leaf, can in any way call to mind the wonderful mechanism which enables the plant to secure the main bulk of its solid substance from the fleeting stores in the circumambient atmosphere; or the manner in which it is dependent on light; or its mineral needs; or its great need of water and its wonderful transpiratory activity? And yet the chief industry of the world is agriculture—the feeding and tending of plants. At least those who lead a rural life should have their imagination excited on such subjects at school; it is even possible that much of the asserted dulness of a country life might pass away if an interest in plant activity were properly cultivated. And schoolmasters might even find comfort in the reflection that, as Messrs. Brown and Escombe have recently shown, the translocation of the material first formed in the leaves, metabolism and growth are become so intimately correlated that the perfect working of the entire plant is only possible in an atmosphere containing the normal amount of three parts of carbon dioxide per ten thousand; they might recognise in the plant an organism after their own heart, with ripened conservative instincts and unwilling to accept any other than the limited diet long favoured by the craft.

In these days not only the obvious but also the microscopic forms of life claim attention: it is imperative that all should be at least aware of their existence and mindful of the deadly power that some of them exercise. All should be able to read with intelligence the wonderful story of the beneficent labours of the great Pasteur—a true saviour of mankind—and appreciate their value. The lessons of sanitary science will never be properly brought home to us and heeded in daily life until a more direct intimacy with micro-organisms is encouraged at school.

And whether or no there be 'good in everything,' children must at least be encouraged to seek it: to use their eyes always and to reflect on what they see. A proper use will be made of leisure and of holidays when they are so trained; even 'Days in the Country' will then be days of enjoyment and peace for all, never of mere vacuous wanderings, let alone of wanton destruction, and will leave no memories of broken glass and waste paper behind them. And in the end, the national drink bill may be considerably diminished if Shakespeare's words come to have some slight meaning for all.

Let us consider what we can do to further this most desirable end. Section L is in advance of the times, being concerned with a non-existent science—the Science of Education. The science will come into existence only when a rational theory of education is developed and applied; but it is clearly on the very eve of coming into existence, otherwise the Section could not have been established; and we may contribute much to its development.

Surely, the primary article of our creed will be that—as Thring has said—'the whole human being is the teacher's care,' for all must admit that the faculties generally should be cultivated and educated. At present we make the fundamental mistake of disregarding this truth but there is evidence that sounder views are beginning to prevail. It is very noteworthy, for example, that in the recent report of the Committee on Military Education it is laid down that *five* subjects are to be regarded as *necessary* elements of a sound general education, viz, English, Mathematics, a Modern language, Latin and Experimental Science. Moreover it is recognised that each of these subjects has a peculiar educational value of its own. Such a conclusion takes the breath away; indeed, it is almost beyond belief that Headmasters of Public Schools could commit their brethren by attaching their names to a report containing such a paragraph as the following:—

'The fifth subject, which may be considered as an essential part of a sound general education, is Experimental Science, that is to say, the Science of Physics and Chemistry treated experimentally. As a means of mental training, and also viewed as useful knowledge, this may be considered a necessary part of the intellectual equipment of every educated man, and especially so of the officer, whose profession in all its branches is daily becoming more and more dependent on Science.'

Just consider what this recommendation means: that it is now publicly admitted by high authority that *all* boys should have the opportunity given to them at school of gaining knowledge *by experience*—by actually doing things themselves, not merely by reading about them or being told about them, because this and nothing short of this is what is aimed at by all who advocate the introduction of Experimental Science as a necessary part of school training. The reign of the cleric as absolute monarch of the school kingdom will be at an end if such doctrine be accepted and acted upon; there will be some chance of our regaining the reputation of being a practical people. Members of the British Association will be carried back in a dream, some thirty odd years, to 1867, when a report from a Committee, consisting of the General Officers of the Association, the Trustees, the Rev. F. W. Farrar, the Rev. T. N. Hutchinson, Professor Huxley, Mr. Joseph Payne, Professor Tyndall and Mr. J. M. Wilson, specially appointed to consider the best method of extending Scientific Education in schools, was presented by the Council to the General Committee and it was resolved: 'That the President of the Association be requested to communicate the Report to the President of the Privy Council,' &c. One among the reasons then given why general education in schools ought to include some training in science was, 'as providing the best discipline in observation and collection of facts, in the combination of inductive with deductive reasoning, and in accuracy both of thought and language.' History does not record what the Privy Council did with the memorial. Had the Council been mindful of its duty to the country and paid serious attention to so weighty a representation our present position might have been a very different one; the German and American bogies would have assumed less portentous dimensions in our eyes, and we might have found ourselves far better prepared than we were to cope with the conditions in South Africa. Accuracy of thought and language, according to the evidence given before the Committee on Military Education, are qualities in which military candidates are particularly lacking, notwithstanding the asserted value of Latin—the chief subject of study in the Public Schools—as mental discipline.

Unless we are prepared to disregard not only all the lessons of the recent war but also the lessons we have been receiving during years past in the wider war of commercial competition; unless we are prepared to disregard the still wider consideration that education must be an effective preparation for life and not merely for business, the findings of the Committee on Military Education must be embodied in our practice. Undoubtedly the real issue decided by the Committee was the question whether the *antecedent*, not the technical, training of military candidates was properly conducted. In other words, *our Public School system was on its trial.* Although not referred to in so many words, this system is most effectively condemned in spirit in every line of the Report and far more between the lines. But the Committee have merely recognised what has been known for years and years; not a single novel point is brought out—not a single novel issue is raised in their report. By making definite recommendations, however, they have lifted the subject on to a higher plane, and it is these recommendations which require the most careful consideration *and revision*: for if carried out as they stand there will be little improvement in our condition. The Committee have certainly done more than they were asked to do, but not more than they were bound to do. By the terms of reference they were to consider and report what changes, if any, are desirable in the system of training candidates *for the Army* at the Public Schools. Instead they have recognised that education at secondary schools has in a great measure conformed to the course generally prescribed by public professional examinations originally designed to secure the selection of candidates who had availed themselves of the advantages of a good general education; and that the State has been careful in the matter of examinations that they should be so framed as not to disqualify or hinder the unsuccessful candidate from entrance into other professions: or, in other words, that neither more nor less is to be exacted from candidates for entrance into the Army than from candidates for other professions. Consequently, the requirements to be laid down for Army candidates are such as can be met from a sound general education; they are in no way special. The Committee have, in fact, pronounced judgment on the subject of all others which is of greatest consequence to the nation at the moment. But they were not actually appointed for such a purpose, although they should have been, as it was to be foreseen that the major issue must be tried if the minor were to be settled. The modern spirit in education was not sufficiently represented on the Committee. Of the witnesses examined too few had any practical acquaintance with the work of education, although a great many who could judge of its effects gave evidence; and the practical side of education was scarcely considered. Only one witness was examined on behalf of 'Science'; Mathematics was unrepresented. Such being the case, it is surprising that the Committee should have gone so far in their recommendations and a proof how overwhelming the case must be in favour of change.

Among the signs of the time showing that liberal views are coming into vogue, I may refer to the provision made in the new buildings designed by Mr. Aston Webb and Mr. Ingress Bell for Christ's Hospital School, which was removed from London in May last. The new home of this ancient foundation is situated in the county of Sussex, about four miles south-west of Horsham, and comprises an area of 1,300 acres of land—meadow, arable and woodland. Nearly 600,000*l.* has been expended on the new school up to date. Provision is made for 800 boys, and together with the necessary staff these will form a colony of some thousand persons. The school provides its own water supply, disposes of its sewage by the bacterial system on its own premises, and is lit entirely by electricity generated on the spot. Only food and clothing are derived from the outside. If senior boys, in the future, are allowed to gain some insight into the interior management and economy of such an institution, what wonderful opportunities they will enjoy! And I hope the day is not far distant when boys will learn to understand everything connected with the school in which they pass so many years of their lives. A school should be the last to deny to boys every opportunity of gaining such invaluable experience. Fortunately Christ's Hospital School is conducted on the hostel system; the masters therefore are not charged with household cares and have no temptation to withdraw their thoughts from the work of education. The school has no taint of commercialism about it. It will be a happy day for our country when this is true of all our schools.

The school buildings are placed nearly in the centre of the site and cover an area of about eleven acres. They are disposed along a slightly convex line facing southwards, the extremities curving gently towards the east and west respectively. The main range has a frontage of 2,200 feet. At the eastern end, detached from the main range and somewhat retired, are the Infirmary and Sanatorium, which have a frontage of 500 feet. There are extensive playing fields and also a Gymnasium and Swimming Bath.

The scholastic buildings are grouped in the centre around a 'Quad,' 300 feet by 240 feet.

The Dining Hall, 154 feet by 56 feet, behind which are the Kitchens and subsidiary offices, is placed on the north side of the Quad. The Chapel has sole possession of the western side. The School Hall, 130 feet by 50 feet, is at the centre of the southern side, class rooms being provided in two buildings parallel to it but separated by intervals of 40 feet.

The Science School faces the Chapel, filling the eastern side. The Art School and Library are arranged at right angles to it, somewhat in the background. The Science School consists of four main 'laboratories,' with subsidiary smaller rooms attached to each. No lecture rooms are provided, as Science is to be studied at the work bench; but each of the laboratories has a space arranged so that demonstrations may be conducted within it. The laboratories are fitted up as workshops as well as in the ordinary way, so that boys may use tools as well as test tubes, and the effort has been made to keep the fittings as simple as possible. Workshops for specific manual instruction will be provided in addition to the Science Schools. Experimental Science will be taught throughout the school. It will be obvious that body, mind and soul have all been cared for. Whilst due provision has been made for the intake of that energy which is so indispensable to the indulgence in mental effort as well as to the maintenance of the vital machinery, science has received recognition at the hands of the designers of the Buildings, of the Governing Body and of the Head Master in a manner heretofore unusual: it has actually been placed on an equality even with religious and with literary study, and it may be hoped that the reverent regard of the beauties and wonders of Nature gained in the Science workshops as well as in the surrounding country will but deepen the feelings of devotion proper to the Chapel and greatly help in lifting the life of the school to a high level. May the example not be without effect.

It has been my privilege to act as the nominee of the Royal Society of London on the Governing Body of the School during several years past and I may be permitted to bear witness to the manner in which one and all have been mindful of the needs of the times in arranging the new buildings. I believe few Governing Bodies of Schools will do otherwise than promote advance, if properly advised. Resistance to progress comes from within the schools. The public must force the schools to reform.

Let me now return to the recommendations of the Committee on Military Education. It is to be noted that they clearly involve the recognition of two sides to education—*a literary and a practical.* I use the term practical advisedly, because it would be wrong to draw a distinction between a literary and a scientific side, as the whole of education should be scientific and science—true knowledge—and scientific method—true method—should pervade and dominate the whole of our teaching, whatever the subject-matter; and as the object of introducing experimental science into the school is to give the scholars an opportunity of gaining their knowledge at first hand—by practical heuristic methods, as distinguished from literary didactic methods—the introduction of such discipline may be properly said to involve the recognition of a practical side.

The term practical must not be understood as the antithesis of theoretical. Practice is inseparable from theory in all true teaching, the advance from one practical step to the next being always over a bridge of theory. But if it be granted that education necessarily has two sides, it follows that the Committee on Military Education are illogical in their recommendation that Latin and Experimental Science may be treated as alternative subjects: they are but complementary, not alternative, subjects. The only possible alternative to Latin would be a subject in the literary branch—another language, in fact.

But the recommendations of the Committee are also far from satisfactory on the subject of languages. 'The study of languages,' they say, 'forms a third main feature of a sound general education. Of these the most important, from an educational point of view, is Latin. Modern languages, though much inferior to Latin as a means of mental discipline (at least as generally taught), must none the less be regarded as an important part of a sound general education.' In face of this conclusion it would have been logical to make a modern language rather than Latin the alternative to experimental science: obviously the Committee dared not omit the modern language. It is true the recognition of experimental science and Latin as possible alternatives may be regarded as a high compliment to the latter, but it was never intended to be such; in truth it marks the recognition of the inevitable: that Latin will ere long be deposed from its high estate, and intellectual freedom granted to our schools, greatly to the advantage of Latin, I believe. There is no doubt that the relative value of Latin as an educational subject is grossly exaggerated; those who dwell on its merits are rarely conversant with other subjects to a sufficient extent to be able to appreciate the effects these would produce if equally well taught. As a matter of fact, in the case of Latin the most capable teachers have been chosen to teach the most capable boys; the results obtained have been unfairly quoted in proof of the superior value of the subject. We have yet to discover the highest value of other subjects, their depth of power as disciplinary agents having been most imperfectly sounded. And if we consider results, do not they afford proof that the belief in Latin (as taught) is misplaced? It has been the staple subject of education and has been supposed to afford the most valuable training possible in composition.[1] Nevertheless the complaint is general—not only here but also in Germany where Latin is far more taught and believed in—that composition is the one subject of all others which the schools do not teach. The fact is, Latin is a subject which appeals to the minority of scholars; the time of the majority is wasted in studying it. I would give to all an opportunity of proving their aptitude in Latin and Greek, or at least some opportunity of appreciating the construction of these languages; but I am inclined to favour the proposal—made by high authority, I believe—that such studies should follow that of modern languages rather than precede it. The true study of classical languages should be reserved for the University. In any case, it is beyond question that a very large proportion of those who would make magnificent officers are incapable of learning Latin to advantage; such will in future enjoy the inestimable advantage of studying Experimental Science; but if those who take up Latin are in consequence to lose all opportunity of acquiring some power of reading the secrets of Nature and of thereby developing thought-power and mental alertness—and such must be the effect of the adoption of the recommendations of the Committee—they will prove to be of little value to the army in comparison with their colleagues whose eyes have been trained as well as their 'intellect.' In the course of the evidence given to the Committee, Dr. Warre expressed the view that Science would kill Latin eventually. Nothing could be more unfortunate, but the course adopted by the Committee is that most calculated to bring about such a result, as Latin is thereby put in competition with a subject which must ere long be regarded as a necessary subject of school instruction under all conditions. Latin should be made one of the optional subjects along with Greek.

In their scheme of marks for the examination, the Committee put Latin, French or German and Experimental Science on an equality by assigning 2,000 marks to each; but English and Mathematics are rated at a higher value, each receiving 3,000 marks. It would have been better to have assigned equal values to the several group-subjects regarded as essential to a sound general education. It should scarcely be necessary to put a premium on the proper study of a man's own language; the subject has naturally a great advantage over others. As to

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[1] Dr. Warre was continually harping on this point in his questions to witnesses examined by the Committee. Thus (Q. 3,124): 'I want to put Geography and History into English, and your composition would be tested in that way. We think, for instance, that Composition is admirably taught by translation from Latin or Greek. (To the witness:) Would you agree with that, that translation from another language is teaching English Composition?'

Again (Q. 3,129): 'When officers have talked to us of the uselessness of Greek and Latin, they have neglected the fact that Greek and Latin are the great instructors in English.' *Witness* (the Rev. A. Robertson): 'I quite concur in that.'

Mathematics, there is no doubt that this also is a subject of which the relative value as mental training has been greatly over-valued; moreover that the methods adopted in teaching it have been very faulty: consequently much time has been wasted and its true value has not been appreciated, as it has been made to appear unnecessarily difficult and forbidding. The evidence before the Committee against Mathematics being carried too far was very strong. Thus Captain Lee, in examining Major-General Sir C. Grove (speaking of the training at Woolwich), said (Q. 604): 'There was an immense amount of pure mathematics and so forth, which one never has occasion to utilise afterwards, unless one becomes an Instructor of Cadets at Woolwich, where you teach them the same useless things you have learned yourself.' This elicited from General Grove the reply: 'Well, there is a strange tendency in Mathematics—I do not know why—that wherever you introduce them they encroach horribly. I am always struggling to cut down advanced mathematics.' And more to the same effect. Again, Lieutenant-Colonel S. Moores, when asked whether he considered the syllabus for the entrance examinations at Woolwich and Sandhurst to be reasonable (Q. 2,353), at once replied, 'No, sir; Mathematics are, in my opinion, very much over-valued as a subject for Army examinations, excepting for the Royal Engineers.'

After all, if reasonable standards were adopted both in Mathematics and Latin, these subjects would not create the difficulty they do in examinations at present by absorbing so much of the time in school that no proper attention can be given to subjects in reality at least of equal importance. It should be insisted that fundamentals be thoroughly taught by practical methods, so that the knowledge acquired may be real and usable: it is astonishing how far students may be carried in Mathematics, how real and interesting the subject becomes to them, when they grasp the fact that it has a practical bearing.

While dealing with Mathematics, I cannot refrain from quoting a statement made by Captain Lee (Q. 4,209) with regard to the relative values of this subject and of science to military men, as the opinion he expressed is of very general application. 'I think it is quite true,' said Captain Lee, 'that a great number of Artillery officers do go through their service without using Science, but I think they feel that any science they know proves of much more practical use to them in their profession than the Mathematics they have learned. As far as I know, in the most scientific branch of the Artillery, the Garrison Artillery, there are practically no occasions where a knowledge of Mathematics is required beyond the Mathematics necessary to solve a simple formula, whereas the lack of knowledge of Electricity, Steam and Hydraulics is often a serious handicap to the officer.' I will venture to enlarge on this, and say that, assuming Latin, Mathematics and Experimental Science were taught equally well, by equally sound methods, and that they proved to be of equal value as forms of mental training (though, of course, developing somewhat different faculties), the training gained through Experimental Science would be far the most valuable because the recipients would be brought thereby most intimately into contact with the world and most fitted to help themselves by having their thought-power developed. Of course this is but an opinion, but one, I venture to think, which many share with me; yet I make no superior claim for the subject and ask only that it should rank equally with literary and mathematical training among the necessary subjects of education.

It still remains to consider the specific recommendations of the Committee with regard to Experimental Science, as these are most unsatisfactory. Nothing could be more satisfactory than the manner in which the subject is dealt with by the Committee in their general report, paragraph 20, already quoted (p. 828). But on turning to the scheme of the proposed examination (Appendix A), it appears that not one Experimental Science but two Experimental Sciences are contemplated, viz., Physics and Chemistry, either of which may be taken in preference to Latin and together with English, Mathematics and French or German. A most important issue is involved in this recommendation; it cannot be too strongly opposed.

It is very strange and proof how little we are accustomed to act consistently or to organise, that having found a good thing we rarely make use of it. In the early days of scientific teaching the elementary parts of chemistry and physics were taught as one subject; but gradually, as the individual sciences developed, this healthy practice fell into abeyance. Then time brought its revenge: it was seen that a very one-sided creature was being trained up; that the subjects were in reality interdependent. Moreover, a revolt had been setting in against the formal stereotyped manner in which chemistry was being taught in the schools; this came to a head about 1887, and a better policy was inaugurated by the Reports and scheme presented to Section B of this Association in 1889 and 1890, which condemned 'test-tubing' in favour of problem work and led to the introduction of the quantitative exercises which are now generally admitted to be of the first importance. Although the scheme dealt primarily with chemistry, being the work of the Chemical Section, it yet had a physical basis; physical measurement, in fact, was its life blood, and all the earlier exercises prescribed in it were in essence physical exercises; moreover the importance of paying some attention to bio-chemical and bio-physical phenomena was not overlooked. As teachers have gained experience of the educational value of the heuristic methods advocated in the British Association scheme, they have been led to apply them more and more widely, and the teaching of Elementary Science has in consequence been regarded with growing favour of late years; more and more has been done to give it the necessary breadth so as to constitute it an effective system of 'Nature Study.'

The University of London—not the reconstituted body of the present day, but the much-abused examining body of the past—after careful inquiry a few years ago advisedly substituted the subject of General Elementary Science for the specific sciences previously prescribed for the Matriculation Examination: by so doing it took a forward step which has generally been admitted by those who can really appreciate the issue to be one of the most important possible from an educational point of view. But the syllabus was imperfectly drawn up—although it had many good points—and the examination was entrusted to men who, besides having little sympathy with the subject, had scant knowledge of school requirements and possibilities. Consequently, the examination was a failure, as everyone foresaw it would be if conducted without proper consideration. The new University has taken the *most unwise* step of reverting to single subjects. It has done far worse than this, however, in making 'science' an alternative subject. Such a reversal of the policy so long pursued by its forerunner can only be described as a *National disaster*. I make this statement with utmost consideration and trust that the fact that it is so pronounced from the Chair of this Section may give increased force to my opinion.

It may be claimed that the action taken by the Committee on Military Education is in harmony with that approved of by the Senate of the University of London. The only comfort left open to us is that afforded by the proverb that two wrongs do not make a right. Let us hope that wiser counsels will ere long prevail. The consequences of perseverance in so narrow a policy must be very serious. Consider the effect even from a limited professional point of view. It is widely felt that, owing to the growth of knowledge, it is necessary to specialise if we are to do effective work; but this does not mean that we should be uncultured. We know that the very contrary is the case; that there was never a time when general knowledge was of greater value than it is at the present day. Yet how little this is recognised. The physicist is already unable to understand the chemist. And although the biologist is attempting to unravel almost transcendental problems in chemistry, he has but the most rudimentary knowledge of the subject. What intellectual pigmies we shall be if we pursue so short-sighted a policy; how ineffective must be our treatment of borderland problems. How little right men of science will have to reproach those who have received only a classical and literary training with lack of general culture if we remain so narrow within our own domain. And from a general point of view the outlook is still more serious. The object of introducing Experimental Science into schools is to give training in knowledge of the world: to cultivate appreciation of its beauties and mysteries. To do this involves resort in some measure to all the sciences. Chemistry and physics are put first merely because they are of fundamental importance, chemical and physical changes being at the root of all natural phenomena.

As to the value of 'Science' to military men, it is easy to understand that they should have little conception what it may do for them: having never received proper training hitherto, they cannot have had the opportunity of testing its usefulness or of appreciating its merits. But making all allowances, it is difficult to understand an answer such as that given by Lieutenant-Colonel Murray (Q. 4,806) to the Committee on Military Education, viz., that 'Science is a narrowing study for the young mind, and we want to widen and open the mind as much as possible; let them learn their science afterwards' (that is, after the entrance examination). The contention of the advocates of 'Science' has always been that of all subjects it tends most to widen and open the mind. Why attention should be specially called to this answer by the Committee in their report is a riddle; I hope it was because they desired to show they could rise superior to the occasion. But the idea that science 'can be learnt afterwards' is a very common one, and one of the most pernicious abroad. Learning from books and teachers is a lazy and ineffective method of learning; the average scholar is corrupted at an early age by exclusive resort to such methods. Much of the mental inertness of the day is acquired at school by over-indulgence in book study. But apart from this, early youth is the period when the mind is most alert and the desire to acquire and experiment greatest; it is the time when the powers of observing and of reasoning can be most easily developed into fixed habits; in fact, if they are not then developed, it is only in exceptional cases that the omission can be rectified in after life. It is too cruel that Mr. Shenstone, the one witness on the subject heard by the Committee on Military Education, should have given expression to the ill-considered opinion that the beginning of the study of Science necessarily comes somewhat later than that of Latin. The statement shows how prone we are to draw false conclusions, how little we think before we speak. The study of Science begins when the infant opens its eyes; every step it takes when it toddles is an attempt to apply the methods of experimental science; some training in scientific method is given in well-conducted Kindergarten schools; but when school is entered, the curtain is suddenly drawn upon all such rational study: if it be the fate of the child to enter a Preparatory school prior to entering a Public school, he is at once referred back to the times of the Romans and Greeks, his teachers being oblivious of the real lesson to be learnt from the study of the scholastic methods of classical times: that the training given to the youth should be such as to fit him to do his work as a man. How can our officers, how can any of us, be otherwise than ill-prepared to do our duty in the world when we are so treated as youths?

Of course all such narrow views, all such narrow actions, as those I have referred to are but consequences of the lack of imaginative power—of our failure to make any scientific use of our imagination. Surely it were time we recognised this; that we sought to do our duty towards our children. An Arnold who could introduce morality into school method, not merely into school manners, would be a precious gift to the world in these days. Steeped as we are in mediævalism, we need some cataclysm—some outburst of glowing sand and steam such as the world has recently witnessed in the islands of Martinique and St. Vincent—which would sweep away preconceived opinions and give clearness to the atmosphere. American industry is distinguished by the readiness with which manufacturers scrap their machinery and refit. Why cannot we agree to scrap our scholastic and academic ideals, if not our schools and schoolmasters, and refit on scientific lines? If we are to weld our Empire into a coherent whole and maintain it intact, we must do so. Unless we recognise prophets—if progress be allowed to depend on the multitude—we shall perish. And time presses; we cannot with safety much longer remain a 'nation of amateurs.' An appeal must ere long be made to the masses to enforce the provision of leaders; it must be urged upon the men that they see to it that their masters are educated: for however democratic we may be in our ideals, history teaches, in a manner which admits of no denial, that leaders are the salt of the earth; and in these days leaders need a deal of training to be effective.

Unfortunately it too often happens that those placed in authority are the very last to attempt to march with the times. Bodies such as our Universities, the Education Department and the Civil Service Commissioners might have been expected to lead the way, to keep the most watchful eye on all that was happening, to note and apply all improvements. The very contrary has been the case. As a rule, they have advanced only under severe pressure from outside, scarcely a change can be credited to their initiative. It does not seem to have occurred to them that an Intelligence Department would be a desirable appendage. All suffer from the fatal blot that discretion and authority are vested only in a few heads of departments; the younger and more active spirits have no opportunity granted them while their minds are plastic, full of courage and instinct with advance: so when the time comes that they can act they have lost the desire through inanition. This is the terrible disease from which all our public offices and many industries suffer. It is right to accord experience its proper value, but it is wrong to put aside youthful energy and inventiveness. Our American cousins owe their advance largely to the recognition of these facts.

At bottom the spirit of commercialism is the cause of much of the contorted action we complain of. Neither Cambridge nor Oxford will take the step which has long been pressed upon them—and never more eloquently than by the Bishop of Hereford in his paper read before this Section last year—to make their entrance examination one which would be in accordance with our knowledge and the recognised needs of the times, one which would have the effect of leading schools generally to impart the rudiments of a sound general education. They cannot act together and are afraid to act singly, each fearing that it would prejudice its entry if it took a step in advance and in any way sought to influence the Schools. The Colleges vie with each other in securing the best scholars in the hope of scoring in the general competition. And the Schools have discovered that successes gained in examinations are the most effective means of advertising: they are therefore being turned more and more into establishments resembling those engaged in the manufacture of *pâté de foie gras*, in which the most crammable are tutored without the least consideration of the manner in which lifelong mental biliousness is engendered by the treatment. Parents, with strange perversity, worship the success achieved by Tom and Dick, Mary and Jane, and think they are doing their duty by their children in allowing them to be made use of—for private ends. The worst feature of the system is the narrow spirit of trades unionism which it has engendered, which leads to the worship for ever afterwards of those who have gained the prizes, instead of regarding them but as victors for the moment and requiring them at each step to give fresh proof of power. Nothing is more unwise than the way in which we overrate the pretensions of the 'first class' man; we too often make a prig of him by so doing. Those who succeed in examinations are too frequently not those most fitted for the work of the world. A long experience has convinced me that the boys a few places down a class are, as a rule, the best material. Those at the top may have acquisitive power, but more often than not they lack individuality and the power of exercising initiative. We must base our judgment in the future on evidence of training and of general conduct, not on isolated examinations. If any sincerity of purpose be left in us, if any sense of the value of true training—of what constitutes true training—can be rescued from the scholastic wreck on which we find ourselves at present embarked, we must institute some form of leaving examination which will give the requisite freedom to the schools and every opportunity for the development of individuality but at the same time necessitate thoroughness of training and patient regard of every grade of intelligence; leaders will show themselves and will not need to be examined for. Examinations as commercial enterprises must suffer an enforced bankruptcy.

Racing studs must be regarded as luxuries in schools and kept apart from the ordinary stables, these being regarded as the first charge upon the establishment, as the serious work of the world will fall upon their occupants. In other words, special provision must be made for scholars: they must not be allowed to monopolise attention and set the pace to the detriment of the majority. When Carlyle made the statement that we had in our islands a population of so many millions, mostly fools, he stated what is only half a truth. He failed to realise that the foolishness is very largely begotten of neglect and want of opportunity, not innate. Our schools mostly fail to find out the intelligence latent in the great majority of their pupils, and give it little chance of developing by offering them a varied diet from which to select. During a long experience as a teacher, I have over and over again seen weaklings develop in course of time into strong men when they have been properly encouraged and an opportunity at last found for the exercise of their 'talents.' The Briton is in this respect a most mysterious creature: you never know when it is safe to call him a fool. All are agreed that the mistakes in the recent war were not due to lack of intelligence but to lack of training. There can be no doubt of that. All who have taught in our colleges will, I am sure, agree with me that the material sent up from the schools is in substance magnificent but too often hopelessly unfit to benefit from higher teaching. The things said of those who enter for the military profession are as nothing in comparison with what could be said of those who enter for the professions generally. If our young people fail to show intelligence in later life, it is as a rule because the conditions under which we place them in earlier life are not only such as to leave their intelligence undeveloped but—what is far worse—such as to mar their ability. The best return we can make to those who did such magnificent service in the late war will be to take to heart the real lessons taught by the mistakes: to see to it that their children and their successors generally are trained in a happier school than that in which they were placed.

Examining bodies at the present time do not appear to realise the full measure of their responsibility. To examine well is at all times a difficult task, far more difficult than to teach well. The examiner wields a large measure of authority and it is imperative that he should exercise this wisely. Examiners should therefore be chosen with extreme care and with due regard to their fitness for the work; but this too rarely happens: the choice falls too frequently on specialists with little knowledge of educational requirements and possibilities. The examination of boys and girls is far too often put into the hands of those who have no real knowledge of the species and little sympathy with its ways.

There are three courses open to examining bodies—to lead, to maintain themselves just abreast of the times, to stagnate. As a matter of fact, the last is that almost invariably chosen—a syllabus, when once adopted, remaining in force year after year. Consequently, examinations tend to retard rather than to favour the introduction of improved methods of teaching. It is impossible to justify a policy which has such results. The evil effect of examinations would be less if the syllabus were abolished and the limits of examinations very broadly indicated; this is done in some cases and might be in all. The incompetent examiner and teacher are not in the least helped by the conventional curt syllabus, but the liberty of action of the competent examiner and teacher and their desire to effect improvements are materially limited by it. The competent examiner should know what is a fair demand to make of a particular class of students and should be in a position to take count of the advances that are being made; the competent teacher should be able to do all in his power to make the teaching effective, and be secure in feeling that his efforts could not fail to be appreciated. To take my own subject, the chemistry syllabus recently laid down for the London Matriculation examination is quite unsuited to its purpose and most hopelessly behind the times. The scheme put forward in the report of the Committee on Military Education is but a bag of dry bones. In the case of several subjects, the South Kensington schemes are full of the gravest faults, their hoary antiquity being their least objectionable feature. Surely a national institution, dispensing public funds, should be the last to hold back the nation; it should be provided with machinery which would enable it to march with the times. In making this criticism I should like to recognise the great work done by Sir William

Abney in instituting reforms; but one swallow does not make a summer: a self-acting governing mechanism is needed which would at all times maintain the balance of practice with progress.

If we consider the process by which decisions on such matters are arrived at even in the bodies representative of very large interests, it is a curiously imperfect one. Usually very few individuals are concerned. We are all still imbued with primitive instincts. In some way two parties arise and the question is, which shall conquer? More often than not the true inwardness of the issue presented is left out of account—the considered opinion of the day is scarcely asked for or if opinions are collected they are not weighed. Therefore calm reason is rarely the arbiter. The conditions of modern civilisation require that some better method shall be devised which will really enable us to do that which would be of the greatest good to the greatest number. We do not sufficiently remember that while we are tilting, the enemy at our gates is contemplating our failure to maintain and strengthen our fortifications and quietly advancing his forces to the attack. Speaking of the Navy in the House of Commons not long ago, Mr. Arnold Forster said: 'There was a need for some reinforcement of the intellectual equipment which directed, or ought to direct, the enormous forces of our Empire.' Surely we may take these words as true generally.

At the present time, when the responsibility of controlling all grades of education is about to be cast upon the community and the actual call to arms is imminent, it is imperative that a sound public policy should be framed and that nothing should be allowed to stand in the way of the public good. It cannot be denied that School Boards have done most admirable service; but there are many who are convinced that in not a few respects they have been disastrous failures: that we need a wider organisation, penetrated with sounder and especially with more practical views. The one essential condition of success is that the public should treat the matter seriously, realising that their own immediate interests are at stake; that they will be the first to suffer if those who are chosen by them to formulate the new policy and to supervise the work of education are unqualified and, let me add, to emphasise my meaning, unpractical. If the State is to retain any measure of authority, it too must be prepared to exercise that authority wisely. The blame to be put upon School Boards in England for having allowed an unpractical system of education in the schools is as nothing compared with the blame to be put upon the Education Department for having allowed such a system to grow up by the adoption of academic ideals and academic machinery. Until recently, it was a disqualification for an inspector to have teaching experience. A good degree, if not political influence, was the one qualification. Consequently men were chosen whose practical instincts had never been developed, who knew nothing of practical life and of common-place requirements, nothing of children and their ways; with rare exceptions the inspectors could look at education only from between literary blinkers. To intensify the evil the wicked system of payment by results was introduced. An inspector such as I have described, working under such a system, could not do otherwise than destroy teaching.[1]

The first necessary step to take will be to reorganise the Education Department, root and branch; to imbue it throughout with sound ideals and lead it to understand its great importance as the head centre of the Educational system: for disestablish as we may and however much we may favour local self-government, a head centre there must be to correlate the efforts made throughout the country and to distribute wisdom; but its functions will be those of an exchange and inquiry office rather than directive and assertive. At least, such is my reading of the tendency of the *Zeitgeist*. Such a Department will have an Intelligence Board, whose members are partly official, partly unofficial, so that it may maintain itself in constant touch with outside opinion and effort. One function of this Board will be to preside at a monthly bonfire of red tape and official forms; for in future, even if no other subject of Government concern be kept in a lively and living state, education must infallibly be. The whole staff of the office, including the inspectorate, will be required to avail itself of that most valuable institution, the sabbatical year, *i.e.*, to spend every seventh year in some other employment, so that they may not forget that the world has ways sometimes different from those pictured within the office which it is advisable to take note of in education. Refreshed and invigorated, they will return to work, prepared to sacrifice all sorts of traditions and to recognise the existence of short cuts across fields which had before appeared to be of interminable dimensions; and as it will be required that they spend a certain proportion of their close time in the company of children—if they have none of their own—they will learn that a child has ways and views of its own, none the less interesting and worthy of consideration because they are somewhat different from those of grown-up people.

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[1] The inspector destroys teaching, because he is bound by law and necessity to examine according to a given pattern; and the perfection of teaching is that it does not work by a given pattern (Thring).

It is fortunate that the Technical Education Movement has been coincident in England with the development of the School Board system. Those engaged in it have worked untrammelled by official requirements and much original thought has been enlisted in its service. In essence it has always been a revolt against the academic ideals permeating University education and the schools generally; the faults of the schools, in fact, are the more obvious in the light of experience gained in technical education, which will now come to our aid in correcting them.

The really serious tasks before those who direct the work of education in the immediate future will be the choice of a programme and the provision of capable teachers. If they enter on these tasks with a light heart, God help our nation; they will thereby give proof that they have no true conception of the great responsibility attaching to the position they occupy. Let no man offer himself for the work unless he feel certain that he is in some degree qualified.

As to the programme, it may be said that that is for the teachers to settle; and so it should be. But it cannot be denied that by long-continued neglect to read the writing on the wall, they have lost the claim to legislate; they have shown that they do not know how to legislate. The public must lay down the programme in its broad outlines; teachers must fill in the details. The task imposed upon the schools will be to develop the faculties generally—not in the lop-sided manner customary heretofore—and especially to develop thought-power in all its forms and the due application of thought-power.

I believe that gradually a complete revolution must take place in school procedure; that the school building of the future will be altogether different from the conventional building of to-day, which is but an expansion of the monkish cell and the cloister. Instead of being a place fitted only for the rearing of what I have elsewhere termed desk-ridden emasculates, the school will be for the most part modelled on the workshop, giving to this term the most varied meaning possible; a great part of the time will be spent at the work bench, tool in hand. Nature's workshop will, of course, be constantly utilised, and the necessary provision will be made for outdoor exercise and physical training. Scientific method will underlie the whole of education.

It will be recognised that education has two sides, a literary and a practical: that the mind can work through fingers; in fact, through all the senses; that it is not embodied only in the so-called intellect, a narrow creation of the schools. The practical training will therefore be regarded as at least equal in importance to the literary. Heads of schools will not only be potential bishops: almost all careers will be open to them. In fact, I trust the system will be in operation which I have already advocated should be applied to the Education Department: that the members of the school staff will be forced out into the world at stated intervals, so that they may not degenerate into pedants capable only of applying set rules much after the manner of that delightful creation Beckmesser in Wagner's opera 'Die Meistersinger.'

The class system will be largely abandoned. Children's school time will not be chopped up into regulated periods in a manner which finds no analogy in the work-a-day world: instead they will have certain tasks confided to them to do and will be allowed considerable latitude in carrying them to completion. In fact, they will be treated as rational beings; their individuality and self-respect will be developed from the outset. The Boer War will have taught us to adopt open order teaching as well as open order firing. Schools will glory in turning out individuals, not machines. The success of the Americans is largely due to the way in which Republican doctrines are applied to the up-bringing of children in America. We must follow their example and set our children free and encourage them to be free at an early age. The human animal develops at a sufficiently slow rate in all conscience; there is little need for man to retard his own development. School, with its checks upon freedom and individuality, should be quitted at seventeen at latest, I believe, and all subsequent systematic training should take place at college. Boys are kept at school after seventeen mainly for the purposes of the school. It is claimed that by remaining they gain most valuable experience by acting as monitors and prefects; but this experience is enjoyed only by the few and might be obtained at an earlier age. Then it is said that seventeen is too early an age to enter Oxford or Cambridge, but this has only been the case since schools have retained boys to prepare them for examinations and in order that they might assist in the management. I believe that the attempts which have been made in these latter days to do college work at schools and to establish engineering sides in order to find work for senior boys have had a most detrimental effect. It is said that the training given in technical schools is too far removed from practice; but how much more must this be true of technical work done under school conditions? The excessive devotion to literary methods favoured by schools and the older Universities tends to develop unpractical habits which unfit many to face the rough-and-tumble life of the world and is productive of a disinclination for practical avocations. By leaving school at a properly early period this danger is somewhat lessened; moreover it is necessary in many walks of life that school should be left early in order that the school of practice may be entered sufficiently soon to secure the indispensable manual dexterity and habits. For a long time past we have been drifting away from the practical; those who are acquainted with the work of the schools, especially the elementary schools, are aghast at the influence they are exercising in hindering the development of practical ability. We must in some way counteract this tendency. On the other hand we have to meet the views of those who very properly urge that it is cruel to withdraw children from school even at the age we do. The two views must in some way be reconciled. The only way will be to so improve the teaching in schools that school becomes a palace of delight and the continuation school a necessity. The habits formed at school should be such that study would never be intermitted on leaving school. At present, school so nauseates the majority that on quitting it they have neither desire nor aptitude to study left in them: the work done in it is so impossible to translate into ordinary practice, so foreign to outside requirements.

The problem can only be solved by the scientific use of the imagination. The solution I would venture to offer is that an honest attempt be made to teach, not only the three R's, but also a fourth, Reasoning—the use of thought-power—and that a properly wide meaning be given to all the R's.

Of all powers which can be acquired at school, that of reading is of first importance. Let teachers read what Carlyle says in the 'Hero as Man of Letters,' correcting his exaggerations by reading into his words some of the lessons taught by experimental science. Reading is not taught in schools in these days; if it were, people would not waste their time on the rubbish which now figures as literature, for which a rational substitute *must be found.* A well-read man is worshipped at the Universities and is held up to all comers as a pattern. Why should not children be encouraged to be 'well read'? Let us admit this and sow books in their path. Thring, in giving utterance to his 'Practical Thoughts on Education after Thirty Years' Work,' speaks strongly on this point. 'Great interest will make up for want of time. Create great interest,' he says.

These are noteworthy words. 'As soon as children can read throw away all lesson-books for a time. Let them read. Let them read aloud—really read, not tumble through the pages. Give them to read poetry, the lives of good men, narratives of noble deeds, historical stories and historical novels, books of travel, and all the fascinating literature of discovery and adventure. The person who has once learnt to read well is tempted to go on. And such books, selected by a carefully graduated scheme, would supply endless knowledge whilst kindling the mind, without any waste of time from drudgery and disgust. Geography, history, and power of speech are all comprised in such books if properly used.'

Thring here advocates what I would advocate—the *incidental* method of teaching. Why should there be any set lesson in subjects such as history and geography? Nothing is worse, more stereotyped, more cramping to the intellect, than the set lesson of so many lines or pages, of a sort of Liebig's Essence of information, with the attendant obligation of committing the facts recorded in them to memory. The child, like the restive, high-mettled young steed, wants to be off and away—not to be held severely in hand. Why should not the method by which we get up a subject in later life be followed in schools? At least it should be properly tried. Let us give freedom to children and at least during early years lead them to read hard and wisely: they will do so gladly; and give them pictures innumerable in illustration of their reading. And children must not only be taught to read books: they must learn also to regard and use them as sources of information; the habit of flying for information to books must be cultivated. They must be constantly referred to dictionaries and works of reference generally; they must be set to hunt up all sorts of stories. Of course the scholastic Beckmesser will object that such a system is impossible, that there would be an end to all discipline; but to say this is to show a want of understanding of children and of faith in them, and is proof of failure to recognise their power of accepting responsibility when it is properly put upon them. The secret of success lies in beginning sufficiently early; once let them appreciate what they are doing and the majority will work eagerly and spontaneously.

But when the full meaning is given to the first of the R's, it will be held to cover not only the reading of printed or written character but also the reading of some of Nature's signs, to the end that sermons *may be* discovered in stones and good in everything. That is to say, at the same time that they are acquiring the true art of reading, they must be learning the true art of experimenting—to find out things by putting questions of their own and obtaining direct answers. The teaching of the elements of experimental science must therefore accompany the teaching of reading. And great care must be exercised that the palate for experimenting, for results, is not spoilt by reading. The use of text-books must be most carefully avoided at this stage in order that that which should be elicited by experiment is not previously known and merely demonstrated—a most inferior method from any true educational point of view and of little value as a means of developing thought-power. I regard Huxley's physiography, for example, as a type of the book to be avoided until method has been fully mastered. The great difficulty in the way of teaching the art of reading arises from the comparative paucity of readable books for young people. Text-books are not readable; in fact, they tend to spoil reading; and the majority of books are written for grown-up people having considerable experience of the world. The mistake is too commonly made of expecting children to master 'classics.' On the other hand, we need not fear allowing advanced books to fall into the hands of children; they are the first to despise the namby pamby stuff that is too frequently offered to them. A new literature must be created, if education is to be put on a sound basis; something beyond mere word painting is required. Books are wanted, written in a bright, attractive and simple style, full of accurate information, which would carry us over the world and give clear pictures of all that is to be seen as well as of the character and customs of its inhabitants; and books are wanted which, in like manner, would carry us back in time and sketch the history of the peoples of the earth. The various branches of science all need their popular exponents; our books are for the most part too technical; whilst much has been done to advocate the introduction of 'science' into general education, little has been done to make this possible. Unfortunately those who attempt to write readable books are too frequently not those who are possessed of sound knowledge: it is time that it were realised by those who could write well and accurately that there is a duty incumbent upon them; on the other hand, something should be done to stem the torrent of text-books which is now flooding the field of education with the destroying force of a deluge, making proper reading impossible.

The true use of books has yet to be found and admitted; we do not sufficiently recognise their value as stores of information and savers of brain waste. Why should long trains of facts be committed to memory but to be forgotten? It is impossible to believe that such a process is mental training; it must involve loss of energy and mental degradation. In future we must give the training at less cost and teach the art of going to books for minute details whenever they are wanted. Nearly every subject is taught in an eminently selfish manner at the present time, the expert declaring that the learner must become acquainted with all the main facts of the subject, instead of recognising that it is far more important to acquire knowledge of first principles together with the power of acquiring the knowledge of facts whenever these become necessary.

The second R may be held to cover not only mere writing but also composition. Why is the art of composition taught so badly? Because it is impossible even for children to make bricks without straw: they have little to write about under ordinary school conditions. The subject is also one, I believe, which must be taught incidentally, at least during the earlier years, and chiefly in connection with the experimental work; in fact, to make this last the training it should be, an absolute record of all that is done must be properly written out, and while the work is being done too. Many teachers, I know, shy at this, and say that it is their business to teach 'Science,' not literary style; but they are wrong: they must inevitably accept the burden if they are to succeed in teaching 'Science' at all. An experiment, like an act, 'hath three branches'—to conceive, to do, to utilise: a clearly defined motive must underlie it; it must be properly executed; the result must be interpreted and applied. It is only when the motive is clearly written out that it is clearly understood—that the meaning or intention of the experiment is clearly grasped; and this is equally true of the result. Of course, it is necessary to proceed slowly and not to demand too much from beginners; but it is surprising how the power grows. Drawing, of course, must be included under the second R; but this also may with advantage be taught incidentally and only receive individual attention at a later stage, when those who show aptitude in the incidental work have been selected out for higher instruction.

The third R must be held to cover, not merely the simple rules of arithmetic, and all that is necessary of formal mathematics, but also measurement work. Mathematics claims to be an exact subject: therefore it must be treated exactly and made the means of inculcating training in exactness; not on paper merely but in fact. Moreover, physical science reposes on a basis of exact measurement, so that the introduction of experimental work into schools involves the introduction of measurement work as a matter of course.

The fourth R—Reasoning—will necessarily be taught in connection with every subject of instruction, not specifically. It is introduced as marking the absolute need of developing thought-power; and, in point of fact, should be put before all others in importance.

Under such a system as I suggest the time of study would be spent in two ways—in reading and experimenting. But whatever we do let us be thorough; the danger lies in attempting too much, too many things. Each step must be taken slowly and warily and a secure position established before going further.

Ireland is fortunate at the present time in that far-reaching changes are being introduced into its educational system. A body of men are engaged in this work who are, I believe, in every way specially qualified to promote reforms and earnestly desirous of developing a sound policy. The Irish people have rich powers of imagination such as no other section of the nation possesses: it is only necessary that these powers be trained to considered and balanced action to make the Irish capable of deeds before which the splendid achievements of the past will appear as nothing. Of course the development of a true policy must come about slowly, and we must not be too impatient of results, but give every encouragement and all possible support to those engaged in the work. It is before all things necessary to remember that the school is a preparation for life, not for the inspector's visit; in the future the inspector will act more as adviser and friend, let us hope, than as mentor.

Turning to my own subject, the programmes laid down for primary and intermediate schools appear to me to be well thought out and full of promise, the only fault that I might be inclined to find being that perhaps they are somewhat too ambitious. But very able men are directing the work who should be able to see that thoroughness is aimed at before all things. Nothing could be more gratifying than Mr. Heller's statement in the Report for 1900, 'that the Irish teachers as a whole seem to possess a great natural taste and aptitude for science and the method of experimental inquiry.' May they seek to set the example which is sorely needed to teachers in other parts of the Kingdom. I fear there has been a good deal of hand-to-mouth teaching in the past; to avoid this, the teacher should not only have a carefully drawn-up scheme of work, but should keep a diary in which the work accomplished each week is carefully recorded. In this way the weaker teachers will check any tendency they may have to relax their efforts, and inspectors will be in the position to understand at once what progress is being made. Education, unfortunately, is subject to booms as the money market is; just now the 'Nature study' boom is on. We must be very careful not to let this carry us away; whatever is done must be by way of real Nature study, and must have very simple beginnings. In most of the work that is being boomed the presence of the eternal book is only too evident, and such teaching must be worthless. Let the teachers remember that the great object in view is to acquire the art of experimenting and observing with a clearly defined and logical purpose. If they once learn to experiment properly all else will follow. The inspectors must give constructive help to the work; they too must be students and labourers in the cause of progress, not mere commentators. And there will be a great opportunity for experts to assist who can be helpful to schools. Every school should be provided with a workshop, simply equipped with flat-topped tables, in which all the subjects which are taught practically can be taken. Elaborately fitted laboratories are not only unnecessary but undesirable; the work should be done under conditions such as obtain in ordinary life. A due proportion of the school time must be devoted to experimental studies: no difficulty will arise when it is seen that so much else is taught incidentally; and that this is the case must be carefully borne in mind in arranging the curriculum—otherwise there will be much overlapping and waste of time. Lastly, every effort must be made to keep down the size of the classes. I trust that in Ireland the girls will receive as much attention as the boys. Experimental teaching is of even greater value to them than to boys, as boys have more opportunities of doing work which is akin to it in the world. The work done by girls should of course bear directly on their domestic occupations.

If we are to improve our schools the teachers must be trained to teach properly—or rather, let me say, must be put in the right way to teach, because practice and experience alone can give proficiency. This is the most difficult of all the problems to be faced in providing for the future. It is the one of all others to be thought out with the greatest care; in solving it the help of all who can help must be secured. No amount of didactic teaching will make teachers; the training must be practical. To graft on the ordinary training a course of lectures on the theory and practice of teaching plus a certain amount of practice in a school is not enough. How can we attempt to teach the theory and practice of teaching when we are agreed that we do not know how to teach most subjects?

How can a master of method instruct us how to teach subjects of which he has only heard? It cannot be done; in point of fact, we are talking about the thing—beating about the bush—instead of treating the problem as one which can only be solved by experiment. To teach method, you must know your subject; one man cannot know many subjects. Of course there are quite a number of good general rules to be learnt, but the application of these must rest with the specialist; and the only proper way of giving training in method is to teach the subject in the way it seems desirable that it should be taught. The end result of training should be the development of a spirit of absolute humility—of the feeling that no task is so difficult as that of teaching properly, no career in which finality is more impossible to attain to, no career which offers greater opportunity for perpetual self-improvement. The effect of the narrow and unimaginative system in vogue to-day is to send forth a set of young persons who arrogantly consider that they are 'trained'; if they would only think of the amount of preparation involved in training for athletic competitions, or in training race-horses even, they would entertain more modest views and be aware that they have everything to learn when they commence their work. The Beckmessers reign supreme in our training colleges of to-day; they must be got rid of and true modest experts introduced in their place. The test of efficiency must be a real one, not that of a mere final examination. The inspectors must see to it that the instruction is given always with a view to the fact that the students are to become teachers, which at present seems to be the last consideration borne in mind Every effort must be made to secure a higher class of student for the training colleges; a fair secondary training *must be insisted on.* A narrow spirit of trades unionism pervades the primary school system at the present time; School Boards and managers of Pupil Teachers' Centres make no effort to secure the assistance of secondary teachers.

My receipt for a training college would be: Develop thought-power and individuality; develop imagination. Teach whatever will do this most effectively; let special subjects be studied in the way that may best be followed in teaching them subsequently.

It is to the lasting shame of our State organisation and of our School Boards that so little has been done to provide competent teachers.

The future rests with the Universities; but to save the nation the Universities must be practical; broader conceptions must prevail in them. A course of training which will give true culture must be insisted on. The Universities have recently shown a disposition—to use a vulgarism—to throw themselves at the heads of the military authorities and to make special provision for the training of military students. It is much more their office to train teachers. Why should not the example to hand in the engineering school at Cambridge be followed? Why should not a special Tripos be established for teachers in training? I believe this to be the true solution of the problem.

The desire now manifest in several of our large towns to establish new Universities comes most opportunely; it should receive every possible encouragement from all who have the interests of our country at heart. I believe the objections to be altogether fanciful—the outcome of academic views. It is said that the value of the degree will go down like that of Consols. But in what does the value of a degree consist? Simply and solely in the evidence it affords of training. We regard the Oxford and Cambridge degrees as of value because they are proof that their possessors have lived for some time under certain conditions which are recognised to be productive of good. The degrees of other Universities must soon come to be regarded as proof of sound and healthy training. It must become impossible to obtain degrees such as the University of London has been in the habit of awarding, which have been the result of mere garret-study; proof of training will be required of all candidates for degrees.

But I must now bring this Address to a conclusion. The only apology that I can offer for its length is that having had over thirty years' experience as a teacher and being profoundly impressed by the serious character of the outlook, the opportunity being given me, I felt that 'the time has come,' as the walrus said to the carpenter,

> To talk of many things:
> Of shoes—and ships—and sealing-wax—
> Of cabbages—and kings—
> And why the sea is boiling hot—
> And whether pigs have wings.'
> ('Alice through the Looking-glass.')

This list of subjects is no more varied and disconnected—the problems set no deeper—than those to which we must give our attention in dealing with education; and the sooner the fate of the oysters is that of our present educational 'system' the better. Having shown by this quotation that I am not an absolute modern but have some knowledge of the classics, let me finally say, in the words of another poet—of him who on various occasions gave utterance to much wisdom at the breakfast table, that 'I don't want you to believe anything I say, I only want you to try to see what makes me believe it.'

Something more than an apology for an Education Act such as the powers are now engaged in shaping for us must be framed at no distant date, and a determinate policy arrived at. That policy may perhaps be found in the words put into Hamlet's mouth:—

Hamlet. To what base uses we may return, Horatio! Why may not imagination trace the noble dust of Alexander, till he find it stopping a bung-hole?

Horatio. 'Twere to consider too curiously, to consider so.

Hamlet. No, faith, not a jot; but to follow him thither with modesty enough and likelihood to lead it, as thus: Alexander died, Alexander was buried, Alexander returneth into dust; the dust is earth; of earth we make loam: and why of that loam, whereto he was converted, might they not stop a beer barrel?

> Imperious Cæsar, dead and turned to clay,
> Might stop a hole to keep the wind away;
> O, that that earth, which kept the world in awe,
> Should patch a wall to expel the winter's flaw!

Shakespeare thus taught the use of the imagination before Tyndall! The fact that we can now carry our imagination far further afield and contemplate the survival of atoms once embodied in imperious Cæsar in the flowers and fruit which deck the fair face of Nature—a higher end than that Hamlet paints—may serve to justify the adoption of a method he advocated. Modern progress is based on research—the application of imagination. Surely then there is every reason to make the spirit of research the dominant force in education!

The following Report and Papers were read:—

1. *Report on the Teaching of Elementary Mathematics.*

See Reports, p. 473.

2. *On Recent Reforms in Irish Education.* *By* Dr. W. J. M. Starkie.

3. *The Subjects to be Taught as Science in Schools, and the Order in which they should be Taken.* *By* Dr. C. W. Kimmins.

The great reforms which have taken place in recent years in the teaching of science in schools have been due in large measure to the British Association Report on the teaching of chemistry. Similar reports are needed on the teaching of other subjects suitable for instruction in schools. The biological side should receive as much attention as that already given to the physical side, and Committees should be appointed to report on the teaching of natural history and botany.

The sole object of the paper is to concentrate the discussion which will follow on a few main points which deserve special attention.

The Kindergarten, conducted on true Froebelian lines, covering the years 5 to 8, may be regarded as a satisfactory preparation for young children. The Experimental Science Course, based on the British Association Report, covering the years 12 to 16, may also be regarded as satisfactory; but an important point arises as to whether it should be modified in the case of girls. Girls obtain much better results in biological than in physical science.

The interval between the Kindergarten and the Experimental Science Course should be utilised for suitable Nature-study teaching. Natural history and botany are, as a rule, taught very badly in schools. Systematic botany has been the bane of botany teaching, in the same way that qualitative analysis has been the bane of chemistry teaching.

During this interval thorough instruction should be given in practical mathematics, including the mensuration which is generally taken as part of the Experimental Science Course. This should be given in the time devoted to mathematics, not science.

Suggested Scheme.

Kindergarten	5 to 8 years	boys and girls.
Natural History	8 to 10 „	
Botany	10 to 12 „	
Elementary Experimental Science	12 to 14 „	boys.
Advanced „ „	14 to 16 „	

With a possible modification for girls:—

Elementary Experimental Science	12 to 14 years.
Botany (more advanced)	14 to 16 „

The subjects requiring special attention are the teaching of natural history and botany, and the correlation of science and art teaching. The separation of instruction in different subjects into water-tight compartments leads to great waste of energy and time. Subjects taught as science should be judged entirely by their educational, not their informational, value. Hygiene, dealing with the laws of health, should, however, be taught for purposes of information. The subject is too wide, and includes too many branches of natural science to admit of rational treatment without the expenditure of far more time than can be allotted to it.

FRIDAY, SEPTEMBER 12.

The following Papers were read:—

1. *The Introduction of Practical Instruction into Irish National Schools.*
By W. Mayhowe Heller.

The position of educational affairs in Ireland to-day is one of extraordinary interest. Not only have revolutionary changes in administration of primary and secondary education recently occurred, but far-reaching modifications in curricula and methods of instruction have been introduced. These sweeping changes were the result of the recommendations of recent Commissions, and now within the last few days the Commission on University Education has presented its final report.

The Commissioners of National Education, in taking steps to introduce practical instruction into their schools, are attempting to do the work accomplished in the towns of England and Scotland by local educational enterprise.

The introduction of elementary science will be of especial interest to this

Association, as it may be attributed directly to the Committee of Section B, appointed in 1887.

The 'Results System,' having outgrown its usefulness, has given place to an 'Inspection System.'

Practical instruction in National schools before the change took the form of needlework in girls' schools and a little practical science in a very few boys' schools.

The following subjects are now introduced into the curriculum:—(*a*) Manual instruction; (*b*) drawing; (*c*) cookery; (*d*) laundrywork; (*e*) needlework; (*f*) singing; (*g*) physical exercises; (*h*) elementary science.

Most of these subjects are quite new to the majority of the 13,000 teachers, representing 9,000 schools.

To give some preliminary training to these teachers a head organiser and staff of sub-organisers have been appointed for each subject. Classes are established in centres all over the country, which teachers in the neighbourhood attend; grants are made towards the travelling and personal expenses of teachers attending these classes.

The convent schools, which deal with one quarter of the girls in National schools, form a distinct feature of such an organisation in Ireland.

The manual instruction is of that kind generally known as hand-and-eye training, comprising paper-folding, bricklaying, cardboard and wire work.

In elementary science the typical course for boys and girls is based on the 1889 recommendation of the British Association Committee.

Teachers attending training courses must perform all experiments of the course themselves. Free equipment grants of apparatus for manual instruction and elementary science are given to necessitous schools. Very few schools at present have laboratories, but at the same time a great deal of individual experimenting can be accomplished. Object lessons are allowed as a substitute for a systematic course of instruction in experimental science, but these must attempt to achieve the same results as the science lesson, viz., accurate habits in observation, work, description, and reasoning.

The seven training colleges of Ireland have all made adequate preparation for dealing with the new conditions of instruction.

The Commissioners have left no stone unturned to make the changes a possibility and a success. They have provided an expensive organising staff, conducting classes involving great expense both in equipment and travelling of teachers. They have provided free equipment grants for schools, and, in order to ensure efficiency in inspection, have enabled all inspectors to become thoroughly acquainted with all details of the working of the new programme.

The work and enthusiasm of the teachers attending these classes have been beyond all praise. These training classes have been made a really useful and efficient factor in the progress of this educational revolution. With regard to the new programme—which is probably, *on paper*, the best scheme of primary instruction in existence—we must ask for a little *educational faith* on the part of authorities and inspectorate.

In an over-weighted timetable some co-ordination of subjects seems urgently necessary.

Practical instruction in the National school is to-day in Ireland, among many educational problems of importance, probably the one of most urgent importance, in that upon its successful introduction depends the future of technical instruction.

2. *Intermediate Education in Ireland.* *By* R. M. JONES, *M.A.*

3. *Intermediate Education in Ireland.* *By* Rev. Father MURPHY.

4. *The Relation of Technical Instruction to Industrial Development in Ireland.* *By* T. P. Gill.

SATURDAY, SEPTEMBER 13.

The Section did not meet.

MONDAY, SEPTEMBER 15.

The following Reports and Papers were read:—

1. *Report on the Conditions of Health Essential to the carrying on of the Work of Instruction in Schools.*—See Reports, p. 483.

2. *Report on the Teaching of Science in Elementary Schools.* See Reports, p. 481.

3. *Discussion on the Training of Teachers.*

Opened by Miss L. Edna Walter *and* Professor H. L. Withers.

4. *Joint Discussion with Section G on the Training of Engineers.*

TUESDAY, SEPTEMBER 16.

The following Papers were read:—

1. *A Universal Language.* *By* Sir F. J. Bramwell, Bart., *F.R.S.*

2. *Discussion on the Teaching of English*

Opened by P. J. Hartog, *B.Sc*

3. *The Neglect of English Grammar.* *By* Professor Minchin.

The teaching of reading, spelling, and English grammar has disappeared from English schools for what are termed 'the better classes.' Practically, a boy has to learn these subjects in the nursery or not at all; for as they do not count in the system of the public schools the preparatory schools do not teach them, these latter being exact miniature copies of the former.

The result of the neglect of English grammar is a mass of bad composition, instances of which can be collected at any moment from the articles in our leading newspapers, magazines, and reviews, as well as from the works of esteemed authors. A comparatively small number of types of faulty writing are quoted in the Paper.

The neglect of the study of grammar in the schools results also in many errors in ordinary conversation, and, to some extent, in errors of pronunciation.

English grammar is neglected in the schools because these bodies are under classical control, and the masters assume as an axiom that 'when we are learning Latin grammar we are learning English.'

A change in the head-masterships of the schools is necessary, both in the interests of modern science and in those of modern languages. These schools have been too long under classical and clerical control.

4. *Joint Discussion with Section A on the Teaching of Mathematics.*

5. *On the Teaching of Elementary Mathematics. By* A. W. SIDDONS, *M.A.*

A little more than twenty-five years ago the British Association and the Association for the Improvement of Geometrical Teaching (now called the Mathematical Association) worked at this question; the ends aimed at were not gained in their entirety, but much improvement resulted in the teaching of the subject.

That movement has taught us that attempts to secure any but moderate reforms are doomed to failure, and we see to-day from private and published correspondence that mathematical masters generally are anxious for moderate reform, but dread any hasty change.

The Mathematical Association Committee recommends that a first introduction to geometry, and to each new branch of geometry, should be experimental with the use of instruments and numerical measurements and calculations. This recommendation, which is by no means new, seems now to meet with almost universal approval; but, in order to encourage this work, the Report suggests that elementary geometry papers should contain questions requiring the practical use of instruments.

So far as deductive geometry is concerned, there seem to be four alternatives:—

1. To have no one syllabus placed in the position of authority.
2. To replace Euclid by *one* standard syllabus.
3. To modify Euclid by omission and readjustment.
4. To retain Euclid in its present form.

The first of these alternatives would make teaching difficult in classes of boys who have previously used different books following different orders, and also in classes of boys preparing for different examinations which adopted different schedules; any proposal to abandon the use of one definite authority would meet with the strongest possible opposition, and would probably cause Euclid to be granted a new lease of life.

The Mathematical Association Committee has recommended the adoption of a modified Euclid; they considered the time not yet ripe for the proposal of a standard to be finally adopted in place of Euclid.

Though the Committee considered it wise to retain a modified Euclid for the present, I regard the proposal and adoption of a new standard as the next step to be undertaken, and I hope that the Mathematical Association Committee, consisting as it does of practical teachers and examiners, will draw up a tentative syllabus, to be criticised by schoolmasters and others, and finally submitted to this body for confirmation. Such a syllabus should leave great freedom to the teacher and text-book writer; it should be so elastic as to allow of changes from time to time, but sufficiently precise to prevent chaos.

The modifications proposed in the Mathematical Association report include:—

1. The omission of some propositions which do not help on the course, or which should be regarded as axiomatic.
2. Improved methods of proving other propositions, including the use of hypothetical constructions.
3. The addition of a few propositions.
4. The adoption of Playfair's axiom and the 'limit' definition of a tangent.

5. The use of angles greater than two right angles.

6. That the exact treatment of incommensurables be regarded as a branch of higher mathematics.

The report also suggests that in pass examinations the system should be gradually introduced of requiring that a candidate, in order to secure a pass, should evince some power besides that of being able to write out bookwork; the solution of riders and questions requiring the use of instruments would thus be encouraged.

The most important suggestions under the head of arithmetic and algebra are those proposing that the barriers between arithmetic, algebra, and geometry should be broken down, and the early introduction of graphs; there are many other suggestions of too detailed a nature to be considered individually now.

The Arithmetic and Algebra Report may be briefly summed up in the following words:—

The Committee recommend—

(*a*) that *easy vivâ voce* examples should be frequently used in both arithmetic and algebra;

(*b*) that great stress should be laid on fundamental principles;

(*c*) that, as far as possible, the rules which a pupil uses should be generalisations from his own experience;

(*d*) that, whenever practicable, geometry should be employed to illustrate arithmetic and algebra, and, in particular, that graphs should be used extensively;

(*e*) that many of the harder rules and heavier types of examples, which examinations alone compel us to retain in a school curriculum, should be postponed.

Finally, I should point out that the report has been drawn up with a special view to the acquirement of brain-power, which is the most important consideration at this stage of a student's career; but nevertheless if these recommendations are adopted I feel sure the engineers, whom we have to thank for bringing matters to a head by introducing the discussion last year, will find great improvement in the boys sent to them from the various schools—improvement not only in brain-power, but also in mathematical power.

APPENDIX.

Corresponding Societies Committee.—Report of the Committee, consisting of Mr. W. WHITAKER (*Chairman*), Dr. J. G. GARSON (*Secretary*), Professor MELDOLA, Mr. FRANCIS GALTON, Sir JOHN EVANS, Mr. J. HOPKINSON, Professor BONNEY, Mr. T. V. HOLMES, Dr. HORACE T. BROWN, Rev. J. O. BEVAN, Professor W. W. WATTS, Rev. T. R. R. STEBBING, Mr. C. H. READ, *and* Mr. F. W. RUDLER. (*Drawn up by the Secretary.*)

THE Corresponding Societies Committee have to report that the recommendations made by the Delegates at the Conferences held during the Meeting of the Association at Glasgow last year have been carefully considered and have been adopted.

The following covering letter was issued, along with the Report of the Conference of Delegates, to the Secretaries of all the Corresponding Societies on the list and to each of the Delegates :—

Burlington House, London, W.: February 26, 1902.

'DEAR SIR,—I herewith send you a copy of the Report of the Conference of Delegates of the Corresponding Societies held at Glasgow. I also enclose a list of the Committees of the Association appointed at that meeting for the investigation of special subjects in which the co-operation of the Corresponding Societies is desired, together with the names and addresses of the Secretaries, to whom you should apply without delay for specific instructions (beyond those given in the Report, pp. 14–22) as to how the investigations or work should be carried out by your Society.

'You will be good enough to have the Report communicated to your Society at an early meeting, and to impress upon your members the importance of taking part in the work of as many of these Committees and in the investigation of as many of the subjects selected by the Delegates as possible. To this end it is very desirable that your Society, or the Council thereof, should appoint a Special Committee to consider what work can be done by your Society, and to arrange for its being begun forthwith.

'The observations when made should form interesting communications for your Society, and at the same time assist the work of the Committees of the Association.

'Besides adopting the programme of work proposed by the Delegates for the Corresponding Societies to engage in, my Committee have also resolved to accede to the request of the Delegates to ascertain and report to the next meeting of the Association what work has been done by each of the Corresponding Societies during the year towards the investigation of the subjects specified, and what assistance they have individually rendered to the several Committees of the Association desiring their co-operation. I trust that in that report your Society will be mentioned as having taken an active part.

'I am yours truly,
'J. G. Garson (*Secretary*).'

Committees appointed by the British Association which desire the Co-operation of the Corresponding Societies in their Investigations.

Section B, Chemistry.

SUBJECT FOR INVESTIGATION	NAME AND ADDRESS OF SECRETARY
1. To collect Statistics concerning the Trained Chemists employed in English Chemical Industries.	Dr. G. G. Henderson, 204 George Street, Glasgow.

Section C, Geology.

2. For the Registration of all Type Specimens of Fossils in the British Isles.	Dr. A. Smith Woodward, F.R.S., British Museum, South Kensington, London, S.W.
3. The Movements of Underground Waters of North-west Yorkshire.	Captain A. R. Dwerryhouse, 5 Oakfield Terrace, Headingley, Leeds.
4. To investigate the Erratic Blocks of the British Isles, and to take measures for their preservation.	Professor P. F. Kendall, Yorkshire College, Leeds.
5. For the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.	Professor W. W. Watts, The University, Birmingham.

Section G, Engineering.

6. To consider Means by which better practical effect can be given to the Introduction of the Screw Gauge proposed by the Association in 1884.	Mr. W. A. Price, The Mill House, Broomfield, Chelmsford.
7. To investigate the Resistance of Road Vehicles to Traction.	Professor H. S. Hele-Shaw, University College, Liverpool.

Section H, Anthropology.

8. For the Collection, Preservation, and Systematic Registration of Photographs of Anthropological Interest.	Mr. J. L. Myres, 3 Hanover Square, London, W.

Section K, Botany.

9. To consider and report upon a scheme for the Registration of Negatives of Botanical Photographs.	Professor F. E. Weiss, The Owens College, Manchester.
10. For the investigation of the Respiration of Plants.	Mr. H. Wager, Arnold House, Derby.

List of Subjects selected by the Delegates of the Corresponding Societies for investigation by the Corresponding Societies in 1902 *not included in the preceding list.*

Section C, Geology.

SUBJECTS FOR INVESTIGATION	NAME AND ADDRESS OF REFEREE
11. Coast Erosion	Mr. W. Whitaker, F.R.S., 3 Campden Road, Croydon.
12. Record of Bore Holes, Wells, and Sections	Mr. J. H. Merivale, Togston Hall, Acklington.

SECTION D, ZOOLOGY.

SUBJECTS FOR INVESTIGATION	NAME AND ADDRESS OF REFEREE
13. Underground Fauna	Rev. T. R. R. Stebbing, F.R.S., Ephraim Lodge, The Common, Tunbridge Wells.

SECTION E, GEOGRAPHY.

14. Variations in the Course of Rivers and Shape of Lakes.	Dr. H. R. Mill, 62 Camden Square, London, N.W.

SECTION H, ANTHROPOLOGY.

15. Archæological Survey of Counties . .	Rev. J. O. Bevan, Chillenden Rectory, Dover.
16. Ethnographical Survey	The Secretary, Anthropological Institute, 3 Hanover Square, London, W.

SECTION K, BOTANY.

17. Botanical Survey of Counties . . .	Dr. W. G. Smith, Yorkshire College, Leeds.
18. Photographic Record of Plants . . .	Mr. A. K. Coomáraswámy, Walden, Worplesdon, Guildford.

The above list of suggested subjects for investigation by Corresponding Societies in which their co-operation and assistance were desired by Committees appointed by the Association, it will be seen, embraces all the Sections of the Association with the exception of Sections A, Mathematical and Physical Science; F, Economic Science and Statistics; I, Physiology; and L, Educational Science, so that almost every Corresponding Society had one subject or more within its scope.

In order to ascertain how far the Delegates have performed the duty imposed upon them by the rules of the Association, in consideration of which they are made temporary members of the General Committee, and in the case of Societies not represented by Delegates, to learn whether the Secretaries of these Societies have performed their duty of bringing the work of the Association in which the co-operation of the Corresponding Societies was desired before their respective Societies, as well as to ascertain what attention had been given thereto, answers to the following questions were asked on the form of application to be placed on the list of Corresponding Societies for the ensuing year, issued in May last to the Secretary of each of the seventy-six Corresponding Societies on the list and returnable by June 30.

Form of Application from a Society previously on the List.

SIR,—I beg to ask, on behalf of my Society, particulars of which are given below, that it be placed on the List of Corresponding Societies of the British Association for the ensuing year. I have also to inform you that, in the event of this application being accepted, the Society will be represented at the Conference of Delegates to be held during the next meeting of the Association by the Delegate whose name and address are given below.

Name of and Particulars regarding the Society.

Full Title and Date of Foundation	Abbreviated Title	Headquarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications

Corrections and alterations to be made in the spaces below the respective headings.

Name of Delegate ……………………………………………………

Postal Address ……………………………………………………

FURTHER INFORMATION REQUIRED BY THE COMMITTEE.

1. Did your Delegate of last year communicate to your Society the various subjects brought before the Conference of Delegates? } ……………………………………
2. Has his report been published by your Society? ……………………………………
3. If you had no Delegate, was the Report of the Conference of Delegates with the covering letter sent therewith to you as Secretary communicated to your Society? ……………………
4. Has any work been done by your Society or members thereof towards the investigation of the subjects mentioned in the Report and Letter? ……………………
5. Has your Society any suggestion to make as to a subject or subjects for discussion at the next Conference of Delegates? ……………………

(*Signed*) …………………………………… *Secretary.*

……………………………………………………1902.

To the ASSISTANT GENERAL SECRETARY,
Burlington House, London, W.

Twenty-nine of the Secretaries of the seventy-six Societies on last year's list failed to send in the application form by the date specified, and it was not till after a reminder had been sent to them that their returns were received. Seven of the Societies have failed to make any application to be retained on the list.[1] In several cases the application was received without any answers to the questions asked, and had accordingly to be returned for the purpose of being filled up. Such inattention on the part of Secretaries to the business of the Societies causes much additional trouble to the officers of the Association, and, it should be understood, renders the Societies liable to be struck off the roll of Corresponding Societies in consequence of non-fulfilment of the conditions required by the Association. The Committee hope that particular note of this remissness will be made by the Delegates at the Belfast Meeting, and the attention of their Societies called to it.

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[1] One of these has since applied.

There were forty-two Delegates sent by as many Corresponding Societies to last year's Meeting of the Association; there were therefore thirty-six Societies unrepresented at the Conference. The Committee consider that it would be to the advantage of the Societies if a greater number of them were to endeavour to secure the services of representatives who would attend the Conference and bring before them the work of the Association.

Two of last year's Delegates represented Societies from whom no returns have been received, and there is no information as to how they and the Secretaries of the other five Societies which have made no returns performed their duties as regards bringing the work of the Association before their members.

The following analysis of the answers to the questions asked refers to the sixty-eight Societies from which returns have been received, and relates therefore to forty Delegates and to twenty-eight Secretaries of Societies unrepresented by Delegates.

The answers to the first three questions show the extent to which the work of the Association has been brought before the notice of the Corresponding Societies. Seven of the forty Delegates failed to make any report to their Societies regarding the subjects brought before the Conference of Delegates, but in two of these cases the covering letter and report of the Conference was communicated to the Societies by their Secretaries. Thirty-three of the Delegates made reports to their Societies, and in twenty of these cases their reports have been, or are being, published by the Societies. In the other twenty cases, including those in which the Delegates failed to bring a report of the Conference before their Societies, the answer to the second question is a negative. The Secretaries of sixteen of the twenty-eight Societies unrepresented by Delegates at the Conference brought the Report of the Conference and the covering letter sent with it before their respective Societies, but to the rest of the Societies it was not communicated. The net result is that only fifty-one out of sixty-eight Corresponding Societies have had the work of the Association brought under the notice of their members, and this was done by the Delegate in thirty-three instances and in eighteen by the Secretary.

Turning now to the answers to the fourth question: Fourteen of the forty represented Societies answer in the affirmative and twenty-five in the negative, while of the twenty-nine unrepresented Societies five answer in the affirmative and twenty-four in the negative. Thus only twenty out of the sixty-eight Corresponding Societies have, on their own showing, done any work towards the investigation of the subjects proposed to them. Of these twenty Societies eight answer only 'Yes,' but twelve give information as to what they have done. The subjects which they have taken up are the Collection of Photographs of Geological Interest by the Bristol Naturalists' Society, the Caradoc and Severn Valley Field Club, the Croydon Natural History Society, and the North Stafford Field Club; Botanical Survey of Counties by the Andersonian Naturalists' Society, the Buchan Field Club, the Dublin Naturalists' Field Club, and the Leeds Naturalists' Club and Scientific Association; Coast Erosion by the East Kent Scientific and Natural History Society; Ethnographical Survey by the Buchan Field Club; Erratic Blocks by the Hull Geological Society and the Liverpool Geological Society; Photographic Record of Plants by the Manchester Microscopical Society. The West of Scotland Marine Biological Association has been carrying on its scheme for the investigation of the local marine fauna and flora, which, though not on the set programme brought before the second Meeting of the Conference of Delegates, is important local work which but few Societies are in a position to undertake. Seven Societies state that steps are being taken to engage in some of the work suggested by the Association.

Although the results are but small, and only a small proportion of the Corresponding Societies have given any response to the appeal for cooperation made to them, yet the Committee hope that by mentioning the Societies which have taken part in the investigations they were invited to assist in other Societies may be stimulated to activity in future. Many Societies which could have done good local work in several of the subjects suggested for investigation have for some reason or other shown a lack of enterprise which would not have been expected of them; while others, with fewer facilities, perhaps, have shown commendable energy, which the Committee hope may bring its reward.

The fifth question has been responded to by but few Societies. The Committee are glad to be able to adopt the suggestion of the Buchan Field Club to discuss the desirability of a Pigmentation Survey of School Children in Ireland as particularly appropriate for the forthcoming Meeting, and have secured the assistance of Mr. Tocher, who has had much practical experience in the investigation of this subject in Scotland, to open the discussion. The other subject to be brought before the Conference will be 'A Plea for an Ordnance Map Index of Prehistoric Remains,' by Mr. C. H. Read, Keeper of the Ethnographical Department of the British Museum. The Committee are, however, indebted to the Hull Geological Society, the Institute of Mining Engineers, the Astronomical Society of Toronto, and the Liverpool Geological Society for valuable suggestions.

The following Societies having failed to comply with the rules of the Association to make application to be continued on the list of Corresponding Societies, the Committee have no alternative but to recommend that in consequence they be for the present removed from the list:—The Cardiff Naturalists' Society, the Dumfriesshire and Galloway Natural History and Antiquarian Society, the Glasgow Natural History Society, the Liverpool Literary and Philosophical Society, the Malton Field Naturalists' and Scientific Society, and the Penzance Natural History and Antiquarian Society.

Report of the Conference of Delegates of Corresponding Societies held at Belfast, September 1902.

Chairman . .	Professor W. W. Watts, M.A., M.Sc., Sec.G.S.
Vice-Chairman .	Mr. J. H. Merivale, M.A.
Secretaries . .	Dr. J. G. Garson and Mr. E. J. Bles, M.A.

The Conferences were held on Thursday, September 11, and Tuesday, September 16, at 3 o'clock P.M., in the Queen's College.

The following Corresponding Societies nominated Delegates to represent them at the Conferences. The attendance of the Delegates is indicated in the list by the figures 1 and 2 placed in the margin opposite to the name of each Society, and referring respectively to the first and second meetings. Where no figure is shown it will be understood that the Delegate did not attend.

List of Societies sending Delegates.

		Andersonian Naturalists' Society .	Rev. A. S. Wilson, M.A., B.Sc.
		Belfast Naturalists' Field Club . .	F. J. Bigger, M.R.I.A.
		Belfast Natural History and Philosophical Society.	John Brown, F.R.S.
	2	Berwickshire Naturalists' Club . .	G. P. Hughes, J.P.
		Birmingham and Midland Institute Scientific Society.	C. J. Watson.
		Birmingham Natural History and Philosophical Society.	C. J. Watson.
1		Bradford Philosophical Society . .	Dr. D. Goyder.
	2	Bristol Naturalists' Society . .	Professor S. H. Reynolds, M.A.
1		Buchan Field Club	J. F. Tocher, F.I.C.
1	2	Caradoc and Severn Valley Field Club	Professor W. W. Watts, F.G.S.
1		Chester Society of Natural Science, Literature, and Art.	A. O. Walker, F.L.S.
	2	Croydon Microscopical and Natural History Club.	Edward Lovett.
		Dorset Natural History and Antiquarian Field Club.	Vaughan Cornish, D.Sc., F.R.G.S.
1	2	Dublin Naturalists' Field Club . .	H. J. Seymour, B.A., F.G.S.
1	2	East Kent Scientific and Natural History Society.	A. S. Reid, M.A.
	2	Essex Field Club	W. Whitaker, F.R.S.
1	2	Glasgow Geological Society . .	J. Barclay Murdoch.
		Glasgow Natural History Society .	A. Somerville.
		Glasgow Royal Philosophical Society	Professor A. Barr, D.Sc.
		Halifax Scientific Society . . .	W. Cash, F.G.S.
		Hampshire Field Club and Archæological Society.	W. Dale, F.S.A.
	2	Haslemere Microscope and Natural History Society.	W. Whitaker, F.R.S.
		Hertfordshire Natural History Society	H. George Fordham.
		Holmesdale Natural History Club .	Miss Ethel Sargant.
	2	Hull Geological Society	J. W. Stather, F.G.S.
	2	Hull Scientific and Field Naturalists' Club.	T. Sheppard, F.G.S.
		Institution of Mining Engineers .	Professor Henry Louis, M.A.
		Isle of Man Natural History and Antiquarian Society.	P. M. C. Kermode.
1		Leeds Geological Association . .	Edwin Hawkesworth.
1	2	Leeds Naturalists' Club and Scientific Association.	Harold Wager, F.L.S.
		Liverpool Engineering Society . .	Professor H. S. Hele-Shaw, F.R.S
	2	Liverpool Geographical Society . .	Professor Gonner, M.A.
	2	Liverpool Geological Society . .	Joseph Lomas, F.G.S.
		Malton Field Naturalists' and Scientific Society.	M. B. Slater, F.L.S.
1	2	Manchester Geological Society . .	Mark Stirrup, F.G.S.
1		Manchester Geographical Society .	Joel Wainwright.
1	2	Manchester Microscopical Society .	F. W. Hembry, F.R.M.S.
1		Marine Biological Association of the West of Scotland.	Professor Malcolm Laurie, D.Sc.
		Midland Counties Institution of Engineers.	Professor H. Louis, M.A.
1		Midland Institute of Mining, Civil, and Mechanical Engineers.	James Barrowman.
1	2	Norfolk and Norwich Naturalists' Society.	Dr. H. Woodward, F.R.S.
1	2	North of England Institute of Mining and Mechanical Engineers.	J. H. Merivale, M.A.
1		North Staffordshire Field Club . .	R. Hornby, M.A.

		Northumberland, Durham, and Newcastle-upon-Tyne Natural History Society.	Professor M. C. Potter, F.L.S.
	2	Nottingham Naturalists' Society	William Bradshaw.
		Paisley Philosophical Institution	William Beattie.
		Perthshire Society of Natural Science	Henry Coates, F.R.S.E.
1		Rochdale Literary and Scientific Society.	James Ogden.
1		Scotland, Mining Institute of	James Barrowman.
		Somersetshire Archæological and Natural History Society.	Lieut.-Col. Bramble, F.S.A.
		South Staffordshire and East Worcestershire Institute of Mining Engineers.	Professor Henry Louis.
		South-Eastern Union of Scientific Societies.	W. Whitaker, F.R.S.
		Toronto Astronomical Society	W. H. S. Monck, F.R.A.S.
		Tyneside Geographical Society	Herbert Shaw, F.R.G.S.
		Warwickshire Naturalists' and Archæologists' Field Club.	William Andrews, F.G.S.
1	2	Woolhope Naturalists' Field Club	Rev. J. O. Bevan, F.S.A.
	2	Yorkshire Geological and Polytechnic Society.	Professor P. F. Kendall, F.G.S.
1	2	Yorkshire Naturalists' Union	Harold Wager, F.L.S.

First Conference, September 11.

This Conference was presided over by Professor W. W. Watts. The Corresponding Societies Committee was represented by the Chairman (Professor Watts), the Secretaries (Dr. Garson and Mr. Bles), and the Rev. J. O. Bevan.

The Chairman delivered the following Address :—

Since the establishment of the Conference of Delegates in its present form many successive chairmen, delegates, and readers of papers, together with the representatives of the various Sections, have brought before the Conference reasons for its existence or work for it to do.

I trust that I may be pardoned if, in enumerating some of the functions which especially appeal to me, I have been somewhat anticipated by contributors to previous Conferences.

First and foremost in my belief comes the fact that this Conference is the only body which gives a kind of corporate existence and standing to the Local Societies as a whole. It is the only thing which brings the Societies into touch with one another, and it is the only hope that at present exists for united action and systematised work. That delegates should make acquaintance, meet in friendly intercourse, and compare notes as to work done by themselves and one another is also a good side of our gathering which is capable of further development than it has yet received.

Secondly, the annual printing of a list of Societies known to be doing important work, with an index of their publications, is a most useful guide to those desirous of working up the literature of any area. The publications are always of limited issue and still more limited circulation, and they are most difficult to obtain a few years after date. The Association has most wisely treasured the publications which have been sent to it, and it is to be hoped that this nucleus of a valuable and unique collection will be placed where it is widely accessible.

Thirdly, comes the stimulation of mutual example and rivalry. The

Local Societies are especially noted for their wide-reaching aims and the all-embracing list of subjects which they pursue, not less than for the steady, persevering persistence with which they will follow up lines of inquiry often as tedious as they are important. Again, local facilities or individual genius often place one Society or other on some bias or enabled it to do brilliant work in some one direction. The force of such example is never lost upon the other Societies, who may extend and even amplify the results thus obtained.

In the fourth place the Conference has the power, too little used, to ask for grants, and hence to back those of the Sections. This should have the effect of helping on those researches which have a local bearing.

In the last place the Association itself profits in receiving each year delegates from all over the country, being thus aided in maintaining the cosmopolitanism which is one of its leading characteristics.

On looking through the proceedings of the Conference since its beginning I have been struck by the appositeness and importance of the subjects brought before its consideration. I know that you will not all agree with me on this point, but my distinct impression is that the distinguished men who have served as your secretaries have brought much skill and judgment to the task of selection. An improvement might be suggested, all the more readily as it rests in your own hands. I should like to see each year at least one delegate bring up some topic which has been treated with conspicuous success by his own Society—not merely a few casual words dropped into a discussion, but a considered paper dealing with the technique of an investigation, its difficulties and pitfalls, and some of the conclusions to which it is leading. Suggestions, whether from the inside or outside, as to a desirable piece of work which might be carried out are usually barren unless somebody has actually made the experiment and can give hints, warnings, advice, and suggestions for improvement.

It is a good divine that follows his own teaching, and I propose to endeavour to qualify, for the first and last time, in this capacity by following my own advice. I am here as a delegate for two federated Societies, as an old sectional recorder and member of certain committees, and as a former member of the Geological Survey, and still interested in the promotion of geological research. In each capacity I have a word or two to say, some of which may be not altogether devoid of use.

The Caradoc and Severn Valley Field Club publishes a 'Record of Bare Facts,' a county record of weather, plants, animals, rocks, and fossils, so carefully edited that practically nothing but well-verified matters of fact creep in. Such a modest and useful publication is sure to be a valuable work of reference wherever started. But local publication should by no means stop here. The labourer is worthy of his hire and has a right to draw his deductions from the facts that he patiently harvests; but it is not a bad thing to separate, as we do, the fact from the inference.

Many of our older publications are, however, almost unobtainable, even the most valuable of them, and this should, if possible, be remedied by Local Societies. No source of scientific information is more difficult to hunt through than provincial newspapers, or less satisfactory when run to earth; yet this is a favourite vehicle of local effort. May I appeal to Societies to reprint the more important of their papers thus published, to distribute their publications very freely to the libraries and institutions in their own county, and to take care that they are early and regularly supplied to the more central institutions, where they will be frequently applied for when it is known that they are readily accessible? Printing a few extra copies is not expensive when the type is once set, and although it is troublesome for a Society to hold stocks of its publications, it would, if willing to supply back parts at a moderate price, take away all excuse from those writers who are apt to ignore local work.

Uniformity of publication appears to be past praying for, and federation of Societies does not appear to have hitherto been a conspicuous or a lasting success, for reasons which it is needless to particularise. But a common vehicle for the publication of the more important papers of the Societies of a county or some other well-defined area ought to be made a success, even at the cost of considerable sacrifice: it would be an untold economy and convenience to the Local Societies themselves, and to those who wish to buy and use their publications. I should like to mention the 'Irish Naturalist' as an effort in this direction, which has been a conspicuous success for many years.

Then we have museums in the county containing collections of considerable local interest, and this suggests a further topic. Many Societies are handing over their museums to county and town councils, in some cases with considerable success. I would suggest to Societies that they should retain a large share in the control of such museums until the town and county authorities have been thoroughly tried.

At rare intervals there arises in most localities someone with a keen passion for museum arrangement and management. Treasure such a person for all he is worth; work him, unmercifully if necessary, but work him hard; give him a fairly free hand; beg, borrow, or steal for his wants; and get everything you possibly can out of him while he lasts, for such persons die young. If once a museum is got into thorough order, made accessible and attractive, the good effect may last for half a generation—possibly until another prodigy or the paid curator arrives.

As a member of the Association and of some of its Committees I should like to say a few words with regard to matters that have come under my immediate ken.

The Erratic Blocks Committee; that which is tracing the course of underground waters in Yorkshire; the one studying the life zones in the Carboniferous rocks; the new Committee on Triassic fossils, and the ones exploring Irish caves and registering type specimens of fossils—are pursuing lines of research which some Local Societies are sharing, and which others would do well to share. These will be spoken to by qualified representatives at our next meeting.

The taking of geological photographs is a matter which particularly appeals to Local Societies, and has in many cases been taken up with vigour and success. I should like to mention particularly the Belfast Naturalists' Field Club, the Yorkshire Societies, those of Kent and the South-eastern Union, those of Durham, Surrey, Warwickshire, Perth, Manchester, Devon, Leicester, Lancashire, Staffordshire, and other Societies which have afforded my predecessor and myself unfailing and patient assistance. Surrey, Warwickshire, and some other counties are organising a general photographic survey which includes geology, and the Geologists' Association is collecting a photographic register of the large field covered by its excursions. The Warwickshire Survey has blossomed out into the National Photographic Record Association. It is a good thing that such cheaply and easily reproduced records should be preserved locally, but while I venture to hope that the National Photographic Record Association will continue to receive copies of the more important geological record photographs, I trust that the parent Committee of the British Association—which, remember, was originated by one of us, Mr. Jeffs, the delegate for the Liverpool Geological Society—should receive copies of photographs not only of geological records but of typical phenomena.

In my own experience I find that it is through the Local Society that I have come into contact with the individual who is doing the work, and this introduction seems to me to be one of the important functions of the Society.

I have been asked to refer to the scheme for a botanical survey of Britain by counties, as Mr. Smith will not be present. I will see that the topic is spoken to at the next meeting.

I wish next to speak as a geologist and to suggest certain points for consideration by the delegates.

An uncomfortable idea is sometimes conveyed that the mere tramp work of scientific investigation is the meed of Local Societies, and that the comfortable trips and record passages are reserved for the brilliant outside investigator. There is no greater mistake. It is true that I once heard one geologist remark to another, 'You give us the facts and we will draw our own conclusions,' but I am strongly of opinion that the man with the best right and in the best position to draw conclusions is he who finds out and records the facts.

The first geological survey of the country is now nearing completion, and in the maps there is a wealth of raw material for the local investigator. No one knows better than the geological surveyor that his work is only just begun when he has got the lines upon his map; but an impatient Government calls him elsewhere, and he is only too willing to hand over his maps and the threads of his ideas to the local investigator to work out. The further division of the strata, the zonal collection of the fossils, the relations and origin of the igneous rocks, and the fascinating problems relating to the origin of the landscape features, all become for the first time possible with the completion of the 1-inch map.

After the survey new wells, borings, cuttings, quarries, and other sections are opened up, and the Local Society can do excellent work either in the person of the local geologist or, if there be no such person, by giving information, which is always gratefully received and generally acted upon, to the office of the Survey.

As examples I may mention the examination of many new railways, pipe lines, sewers, and other works which have been studied and reported upon locally or from the Survey office. Previous to the survey of Charnwood Forest nobody knew that the Mountsorrel granite had been sculptured by desert wind-storms in Triassic time. But suspecting that such would turn out to be the case, I asked local observers to watch the excavations, with the result that in a few years the necessary evidence was forthcoming.

It has long been recognised that there are two geologies—the superficial and the solid; one dealing with surface accumulations of drift, gravel, and subsoil, the other with the rocks built into the earth's crust. The former obscures the latter on the ground and in the maps, but is very important as the connecting link, through the soil, between the inorganic earth and the life on it. But a third geology is now becoming prominent, especially for economic reasons, and it may be termed abysmal. The upper strata of the 'solid rocks' are often related to the lower, in the same way as the superficial geology is related to the solid; and thus vast mineral riches, coal, iron, minerals, and water in the earth's crust are hidden by the upper rocks, and there is no means of judging their position and trend except by boring through the upper crust.

Until the Government, in the interest of the national weal and wealth, is wise enough to undertake the systematic exploration of abysmal geology, everything must be done by individual effort. If borings are successful the details are kept dark, if unsuccessful they are forgotten. Now whether successful or not from an economic point of view, every boring is most precious for a knowledge of the abysmal geology, and every record lost is paid for five or six times over by some individual, and of course eventually by the nation. The Local Societies may often save this loss by being on the spot, by knowing and influencing the individuals concerned, and by the fact that their interest is scientific and not commercial. To them I would say, get and keep all possible records of borings—honestly if possible, but get them.

Again, the Local Societies are good judges of local needs, and to them the accuracy or inaccuracy of their geological map is vital. It is for them to aid in bringing influence to bear on the authorities when corrections and new surveys are desirable.

The relations of geology and landscape can only be satisfactorily worked out by the local observer, who knows the country in every aspect, and who has time to visit and revisit. This line of inquiry may be expected to yield many new and important results to local inquirers in the next few years.

But the main geological function of the Local Societies is to keep a watchful eye always open. Every new section brings some new information, some alteration or confirmation of previous opinion, some chance for fresh investigation. It is always better that the cream of such work should be skimmed by the local observer if possible, but if he is non-existent it is the plain duty of the Society to call in help from the outside.

Dr. Garson placed before the Conference the Report of the Corresponding Societies Committee presented to the General Committee.

In doing so, he drew attention to the letter sent to the Corresponding Societies and to the Delegates, and especially to the recommendation therein made that each Society should appoint a Special Committee of its own to consider what work it could do to assist in the investigations of the various Association Committees which desired the co-operation of the Corresponding Societies.

He said that although the programme embraced the work of most of the Sections, complaint had been made by one Geographical Society that 'the subjects tabulated do not come within the scope of this Society.' The Delegates, he thought, would be of opinion that 'Variations in the Course of Rivers and Shape of Lakes,' one of the subjects set, was purely geographical, and that the excuse given for not taking part in the work was an idle one, especially as the Society in question had at least two important river-basins within easy reach of its members.

He commented strongly upon the supineness shown by the Secretaries of many of the Societies in making the returns required by the Association for retention of their Societies on the list of Corresponding Societies, and called upon the Delegates to note that the Committee had been obliged to strike six Societies off the list in consequence of the neglect of their Secretaries to make any return whatever, notwithstanding that they had been repeatedly asked to do so.

The manner of bringing the work of the Association in which the Corresponding Societies were invited to take part before the Societies left much to be desired. While some of the Delegates and Secretaries took much trouble to bring the matter before their Societies, others were very lax; seven out of forty Delegates at last year's Conference had failed to make any report to their Societies, and only fifty-one out of sixty-eight Societies had any communication made to them on the subject. The kind of communication made by some of these Delegates was not what it should be. For instance, the report of one Delegate, taken haphazard, was not made till one month before the return of the work done by the Society during the year had to be sent in to the Association. The report submitted to the Society at that late period was so highly unsatisfactory that he read it to show what a report should not be like. He observed that not one of the subjects suggested for investigation by Corresponding Societies is mentioned in this report, nor is there a word in it regarding the contents of the printed report of the Conference sent to the Delegate and to the Society he represented.

Since the Report to the Council was made, the Corresponding Societies Committee have received replies from the Secretaries of the various Committees of the Association and others mentioned in the list as desirous of obtaining the co-operation of Corresponding Societies, to whom the following letter was issued at as late a date before the meeting as possible, so that every Society which had done or attempted to do any work might be credited with it :—

British Association for the Advancement of Science,
Burlington House, London, W.,
August 6, 1902.

Dear Sir,—I shall be greatly obliged by your kindly answering the following questions, which are asked with a view to ascertain what has been done by Corresponding Societies of this Association since the meeting last year at Glasgow with respect to ....

....

in which their co-operation was requested :—

1. Name the Societies from which your Committee have received assistance in your investigations or work, by local observations or otherwise, made by committees or individual members of those Societies.
2. Name the Societies on behalf of which application has been made to you or to any member of your Committee for particulars regarding your investigations, and as to how they could assist therein, but from whom you have not yet received any results.

An early reply will oblige, to enable my Committee to complete its Report for the Belfast meeting.

I am, yours faithfully,
J. G. Garson,
Secretary

The results are as follows :—

5. *Geological Photographs Committee.*—Four Societies have done work in connection with this Committee—namely, the Leeds Geological Association, the Croydon Scientific and Natural History Society, the Belfast Naturalists' Field Club, and the Yorkshire Naturalists' Union ; and two Societies not on the list of Corresponding Societies—namely, the Durham University Philosophical Society and the Geologists' Association of London.

8. The *Ethnographical Photographs Committee* have had inquiries from the Belfast Natural History and Philosophical Society.

9. The *Registration of Negatives of Botanical Photographs Committee* have had inquiries from the Manchester Microscopical Society.

11. *Coast Erosion.*—Mr. Whitaker reports that inquiries were made about this work by the Belfast Naturalists' Field Club and the East Kent Scientific and Natural History Society. The Report of the Committee mentions that work has been done by the Yorkshire Naturalists' Union, the Yorkshire Geological and Polytechnic Society, the Belfast Field Club, and the Hull Geological Society.

12. *Record of Bore-holes, Wells, and Sections.*—Mr. Merivale reports that the North of England Institute of Mining and Mechanical Engineers have decided to publish a supplement to their record of shafts, bore-holes, &c., and have begun to collect information for the purpose.

15. *Archæological Survey of Counties.*—Mr. Bevan reports that the Woolhope Naturalists' Field Club are engaged on this work.

16. *Ethnographical Survey.*—The Buchan Field Club have been continuing their work and publishing accounts of the results obtained by their members in Scotland.

17. *Botanical Survey of Counties.*—Dr. W. G. Smith reports that arrangements have been made to co-operate with the Yorkshire Naturalists' Union in a survey of Yorkshire. Assistance has been given by members of Natural History Societies in Huddersfield, Halifax, and Leeds. Information has also been asked regarding the survey by the Brighton and Hove Natural History and Philosophical Society.

18. *Photographic Record of Plants.*—Mr. Coomáraswámy reports that he had an inquiry for information from the Brighton and Hove Natural History and Philosophical Society.

The work of the Corresponding Societies may be considered to be of two kinds, viz. (1) Educational, by which he meant the diffusion of scientific knowledge among the members ; (2) Research or investigation for the elucidation of the hitherto unknown. While everyone would agree that all the Corresponding Societies are doing excellent work in the former department, unfortunately those who take part in the latter kind of work are but few comparatively. Yet it is *Local Scientific Investigation* and publication of the results thereof which the British Association requires of a Society to make it eligible to be placed on the list of the Corresponding Societies. He therefore hoped that the accounts given of the work done during the past year would bring home to many Societies the information wherein their work is defective and stimulate all the Societies to do more.

Mr. A. O. Walker said that he represented a flourishing society of over 600 members, but none of them were of the leisured class. He thought that from various causes Local Societies were nearly played out.

He had tried over and over again to engage the younger men on the work recommended by the Association, but without success. His society, however, supported a local museum in which was contained a collection of objects special to the district.

Mr. Tocher did not agree with Mr. Walker as regards the Local Societies being played out. The society he represented had during the last year made observations on the pigmentation of over 2,000 children. He wished other societies would take an active interest in this work.

Dr. Henry Woodward said that there were many fields of local knowledge which were not yet exhausted, and he hoped that Local Societies would pursue the work.

Mr. Mark Stirrup pointed out that there was often some difficulty experienced by societies in getting Delegates to represent them at the Conference. The scientific societies also suffer from the counter-attractions offered by the various athletic societies to young men.

Mr. Murdoch regretted the loss of old members who had taken active part in the practical field-work of his society, and he hoped that others might be found to fill their places.

Mr. H. J. Seymour explained that his society had been in the habit of offering a prize for the best map of the local area showing the distribution of heather and illustrating its zoology, botany, and geology.

Mr. J. F. Tocher then read the following paper :—

A Plea for a Pigmentation Survey of School Children in Ireland.

It is a matter of common knowledge and experience, even among the least observant, that there is great variation in the colour characteristics of the general population in the British Isles. The cause of the variation, the exact number of shades of colour involved in it, and the relationship of colour to race are problems of great interest to anthropologists. In a general way we have all some views on this relationship. The inheritance of colour as well as that of other characteristics of our parents scarcely requires proof; it is an everyday experience. There would be a disposition, for instance, on the part of a speculative person to assume a fair-haired and blue-eyed child to be of a Norwegian, a Teutonic, or a Saxon origin. The reason for this is based on the association of these colours with many of the Norwegians and Germans one has met, upon the teaching of history, and upon tradition as to the appearance of these peoples. On the other hand, one might say that a swarthy-skinned, dark-haired, and dark-eyed person had a southern origin, and might be an Italian, a Frenchman, or a Spaniard, for similar reasons. The probability of the inference being correct is greater in the former than in the latter case. The point, however, is that we have here a rough qualitative test of race applied by a general and not a specialised observer. The object of a survey of the colour characteristics of the children of Ireland would be to determine quantitatively the various shades of colour existing among the people of Ireland, and thereby throw additional light on their racial origin. On the Continent a survey of this kind has already been carried out in Germany, Austria, and Switzerland. In Germany the survey of the German Anthropological Society, carried out in 1875 and 1876 under the direction of Virchow, has yielded most interesting results.[1] Virchow found, for instance, that 68 per cent. of the children over the whole of Germany were fair-haired and that 40 per cent. were blue-eyed. If the combination of these two characteristics is considered—that is, what is called the blond type—the proportion was found to be 31·8 per cent. The distribution, however, was not uniform. In North Germany 43 per cent. of the children were of the blond type, while in South Germany the percentage was only 18. This evidence, which embraces the quantitative determination of the colour characteristics, is much more valuable than mere general statements supplied by history. Historical evidence, however, can by no means be ignored, for it forms a basis for deduction as to pre-existing races. This was brought prominently forward in the survey of the school children of East Aberdeenshire, which was carried out by my colleague Mr. Gray and myself in 1896. The hair colour most prevalent among Aberdeenshire children is that of brown in varying shades. It was found, however, that among the 14,500 children surveyed 7 per cent. were red-haired, but in some parts there were 20 per cent. of red-haired children. This high percentage appears to be distinctly peculiar to Scotland, for among the 6,700,000 school children of Germany only ·25 per cent. were red-haired. If one takes the description given by Tacitus of the appearance of the Caledonians to be accurate, it would be open to infer that, among the general population of Aberdeenshire, a distinct group is descended from that ancient and warlike people. I think it can be reasonably advanced that the survey of a county is scarcely sufficient as a basis for ethnological deductions. One has only the statistics from a fraction of the race, and many factors tell against presuming the general population of a county to be an average of the race. The survey of Scotland, however, has now been undertaken by a special committee, and the teachers are to be invited to co-operate and to supply the necessary information by the end of the present year. It is extremely desirable that a similar survey should be carried out in Ireland. The Irish, as a people, are said to be the most ancient in the British Isles, and their early contact with Scotland and the Scottish people is specially interesting to the two countries. The close relationship of the Gaelic language to the ancient Irish points to a time when the Highlanders of Scotland and the Irish formed one racial group, speaking a common language; while the existence and distribution of the lake-dwellings in Ulster and in Galloway point to early immigration from Ireland to Scotland, long before the age of Columcille. The antiquary is engaged in unravelling the mystery of the more complete megalithic monuments such as Stonehenge and New Grange, and the hundreds of fragmentary ones distributed over the British Isles, of which Ireland and Scotland have the larger share. The historian has still—and so has the philologist and everybody else—in the origin of the Picts and the origin of the Scots and Kelts a problem of the greatest difficulty to solve. We can render some assistance in dealing with these most interesting racial questions by accurately describing the physical appearance and the physical characteristics of the people of the present day who speak the Irish, the Gaelic, and the English tongues. This we can do without in the least committing ourselves to what would be quite an erroneous deduction, namely, that all those who speak these languages are necessarily descended from the people who originally spoke them. As a preliminary to the survey of the physical and mental characteristics of a people, the survey of the colour characteristics is of special importance. Such a survey could be speedily carried out under the direction of a special Irish committee, or of the local scientific associations of Ireland. The admirable researches already carried out by Irish societies on Irish antiquities and on Irish history are universally known, and a committee under the direction of these societies would be well fitted to carry out this desirable scheme. In the Scotch survey it is proposed to note the name, age, sex, and birthplace of each child, as well as the colour characteristics. This has already been done in the county of Aberdeen, and an analysis of the surnames and their relationship to colour brought out some striking results. It does not follow *à priori* that there is any general relationship of the one to the other, but from an ethnological point of view it is highly desirable to know whether there is any, and to what extent. If surnames generally show a tendency, as groups, to develop into natural varieties of the population, this would point to the preservation of the leading characteristics in families. The rapid development of statistical science is valuable to the ethnologist, as the methods can be applied in many ways. An important method is that of determining the variability or standard deviation of a group from the average. If this is applied to colour and to the measurements of other characteristics, we have the means at our disposal of determining whether there has been mixing, and, relatively, to what extent the admixture has taken place. Even the bare information as to the frequency of particular surnames throughout Ireland is in itself interesting. In Aberdeenshire is was found that the surname of Milne was the most frequent, while the name of Smith had to occupy a second place. Contrary to all expectation, only 14 per cent. of the names were of Highland origin. The proposed survey, besides ascertaining the colour characteristics, would determine the frequency of surnames in Ireland. One would be able then to say what proportion was purely Irish, and which Irish surnames were the most frequent, besides determining the proportion and frequency of those of foreign origin. These are the leading points in the plea I desire to put forward to-day, to institute a survey of the colour characteristics of the school children of Ireland. Before such a survey can be carried out it is essential that the co-operation of the school teachers of Ireland should be secured. But I do not think there will be any difficulty in this, seeing that the object is to increase our knowledge of the origin and characteristics of the Irish race. This is an object which, in addition to being scientific, may be fairly described as a patriotic one; and in patriotic feeling the Irish people have never been found to be deficient.

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[1] *Archiv für Anthropologie*, 1886, pp. 275–475.

Dr. Henry Woodward suggested that the attention of the Royal Irish Academy should be called to the importance of this subject, and that the Academy be asked to take up the matter and provide necessary funds for carrying it out.

Mr. Bevan recommended that the attention of the Educational Department should be called to the subject.

After some further remarks the meeting was adjourned.

Second Conference, September 16.

Professor W. W. Watts, M.A., M.Sc., in the chair.

The Chairman explained that the special business of this meeting was to hear what the representatives of the various Sections of the Association had to say with regard to the work of those Committees in which the co-operation of the Corresponding Societies is desired.

It was agreed that the several subjects mentioned on pages 852 and 853, which were selected last year for investigation by the Corresponding Societies, be retained on the list and again recommended to them for investigation during the ensuing year, except No. 6, which is to be omitted, and No. 18, which has been amalgamated with No. 9.

No representative of Section A (Mathematics and Physics) was present.

Professor E. A. Letts, D.Sc., Ph.D., as a delegate from Section B (Chemistry), called attention to Dr. Gladstone's communication on the phosphorescence and fluorescence of diamonds, and suggested that opportunity should be taken of examining as many specimens as possible.

In a paper by Mr. J. S. Totton and Dr. Letts the functions of aquatic vegetation in absorbing certain of the nitrogenous constituents of sewage were dealt with, and reference was made to a previous communication by Mr. J. Hawthorne and Dr. Letts on the Seaweed *Ulva latissima* and its relation to sewage pollution of sea-water. It was shown (1) that its tissues contain a very high proportion of nitrogen; (2) that it absorbs ammonia and nitrates with great rapidity from sea-water either naturally or artificially contaminated with those substances; (3) that the *Ulva* only occurs in quantity in those localities where the sea-water is polluted with sewage; and (4) that in both Dublin Harbour and Belfast Lough, which are localities of the kind, a serious nuisance is caused annually by the putrefaction of the seaweed when washed ashore. Professor Letts said that he would be very glad if those members of the Corresponding Societies who were botanists would keep this seaweed under observation, and would report its occurrence in quantity in any particular district, together with the local conditions as to pollution, &c.

Professor Grenville A. J. Cole, M.R.I.A., F.G.S., represented Section C (Geology), and summarised the more important work put before the Section, pointing out how local observation might assist in clearing up such problems as those of the Pomeroy Rocks, the distribution of northern erratics, &c.

Dr. H. Woodward, F.R.S., called the attention of the Delegates to the importance of registering all type-specimens of fossils in the British Isles. Many types were buried in local museums, and the various Corresponding Societies would do excellent service to science by securing their registration.

Mr. W. E. Hoyle, M.A., representing Section D (Zoology), referred to the work in this Section which might be assisted by local observers. Such subjects as the investigation of the insect-fauna of Irish caves, and observations on mimicry in British insects, were cited as suitable for certain local societies.

Dr. H. R. Mill, F.R.S.E., attending as a representative of Section E (Geography), said that he had more than once had occasion to be grateful to Local Societies for important assistance in collecting material for the comprehensive discussion of natural phenomena. There were sometimes difficulties in the way of such societies carrying out researches which demanded the knowledge and application only to be expected from specialists who devoted their whole time to the subject; but the collection of data was an essential preliminary to all scientific work, and for this the societies were admirably suited. There was one way in particular in which he believed the members of Local Societies, especially those in Ireland, could find interesting occupation sure of leading to useful scientific results. He was devoting himself to the collection and discussion of data relating to the rainfall of the British Isles, and in carrying on what was really a national work, though done by the co-operation of the observers themselves, the chief difficulty had been the constant changes in the stations where observations were made, on account of the death and removal of the observers. This difficulty might to a great extent be obviated if every scientific society would make itself responsible (as many already did) for keeping an accurate and continuous record of the fall of rain, or, it might be, a series of records at properly selected places in their own neighbourhood. No element of climate was so variable and apparently so capricious as rainfall: hence the impossibility of having too many gauges, provided they were of good quality, properly placed, and conscientiously observed. At present there were large tracts of country in Ireland, in the highlands of Scotland, and in the Moorland districts of all parts of the country, about the rainfall of which we were almost entirely ignorant. No doubt the mere accumulation of records was an unworthy aim and involved only useless trouble if they were not turned to account. But the rainfall figures were turned to account as soon as received in the compilation of an annual volume containing not only the complete record for the year, but a series of comparisons and discussions—one place and one year is compared with other places and other years. On application to Dr. Mill, 62 Camden Square, London, N.W., full particulars as to observing and recording rainfall will be sent to any-one interested.

Professor S. J. Chapman, M.A., attended as a Delegate from Section F (Economic Science and Statistics), and explained that a Committee of this Section was engaged in investigating the effect of the Factory Acts relating to women on their wages and conditions generally, and that they would be glad of information from any district, or to hear of people who would be willing to do some direct investigating in the matter.

Mr. Mark Barr attended as a representative of Section G (Engineering) and called attention to the Committee for investigating the Resistance of Road Vehicles to Traction.

Mr. G. Coffey, as a Delegate from Section H (Anthropology), brought before the Conference a letter referring to the destruction which is going on on Dartmoor by removing stones from certain ancient monuments for road repairs. This gave rise to a discussion on the protection of ancient monuments, and the following resolution was ultimately passed, on the motion of the Rev. J. O. Bevan:

'From communications received relating to the destruction of earthworks and other historic and prehistoric remains, this Conference is rendered sensible of the necessity for the systematic indexing of important anthropological remains, county by county, with a view to their preservation. It therefore commends the collection of material to Local Societies, and expresses the hope that steps may be taken to co-ordinate the various elements involved, and to arrange for the publication of the work.'

Mr. Harold Wager, as a Delegate from Section K (Botany), called attention to the Committee for the Registration of the Negatives of Botanical Photographs and also to the Committee for investigation of the Cyanophyceæ. It is within the power of many local societies to render material assistance to the work of both these Committees.

At this Conference the following paper was read :—

A Plea for an Ordnance Map Index of Prehistoric Remains.

By CHARLES H. READ, *F.S.A.*

DURING the past few years there has been no little discussion with regard to the preservation and accessibility of the best known and most important of our prehistoric monuments, viz., Stonehenge. The discussion seems to be still proceeding, but it has had one good result in the preservation from wanton injury of this precious relic of prehistoric Britain. A monument so widely known over the whole civilised world, and with an entire literature devoted to its study, would be little likely to fall either into complete oblivion or to be the subject of mischievous spoliation without public attention being vigorously called to the fact.

It is not therefore of Stonehenge that I wish to speak—nor is my plea on its behalf—but rather for its humbler brethren whom the breath of fame has for the most part passed over. I plead for the preservation and intelligent exploration of the many hundreds of remains and sites, of approximately the same period, that are scattered nearly over the whole of our islands.

Britain is not very extensive when compared with the domains of our Continental neighbours. In Roman times it was regarded as very distant from the centres of civilisation, and the very name spelt something like exile to the luxurious Roman officer. But the Roman never thought, and we ourselves, nearly twenty centuries later, are only beginning to realise, how many races had peopled these distant misty islands, one race overcoming the other, intermarrying or supplanting each other, but in any case living their lives here, building their houses, exercising their simple crafts, and finally laying their dead to rest in the manner prescribed by their own peculiar customs. Of all these primitive peoples who lived in Britain for many, many thousands of years before the Roman invasion we have scarcely a word of history. One after another they passed in succession, leaving no mark in the world's history and no trace in the land beyond the humble tumulus for their burial-place or the sacred ring of stones for their temple. Practically until the Roman historians take up the story of Britain there is nothing existing that can be called history. Britain before the Christian era was regarded as a dangerous and entirely inhospitable land whither no sane man would willingly go, only valuable in fact for what could be brought away from it.

By what means therefore are we of this twentieth century to realise the conditions in which our pre-Roman forefathers lived? How are we to construct a true history of their arts of life, their beliefs, their dwellings, or their handicrafts? Unless we are far more careful in the future than we have been in the past, the evidence now available will be swept away, and the story of the Britain of the Britons can never be told.

Our only means of elucidating and making clear the prehistoric condition of our country is by the careful and intelligent exploration of the sites of the dwellings, camps, burial-places, or religious structures raised by the people of those times. By no other method than this can we attain to the knowledge we need, and it should be borne in mind by all who undertake exploration of this character that they have in hand, as it were, a unique record ; a record, moreover, that is destroyed in the reading ; and if the investigator cannot interpret it aright he destroys for ever a page, it may be, of human history, and no one following him can write it afresh. No explorer, no matter how experienced, can predicate what may be the evidence he will have put before him in the excavation of a simple mound or stone circle, and the greatest care and attention are essential if he desires his exploration to be moderately successful.

Here then we have, scattered in almost every parish in the United Kingdom, the raw material, the original documents, from which it is the duty of the archæologist to weave the story of prehistoric Britain. But what are the present conditions of these precious documents? What attention is given to the mounds that cover our downs, to the less prominent stone circles that are to be found scattered over our moors? It is true that monuments of the imposing dignity of Avebury, Stonehenge, and others of great size are not likely to suffer from wanton damage because, like some human beings, their very size is their protection. It is true also that in some localities of the more enlightened sort committees have been formed, and the local societies have been active, for the express purpose of preserving these little noted relics. But vast areas remain, full of prehistoric sites, in which nothing is done in the nature of preservation; and, on the other hand, agricultural operations, building, and the like, are doing a great deal in the way of destruction. No better instance could be brought forward than one of recent date recounted by the Rev. G. R. Buick in the 'Journal of the Royal Society of Antiquaries of Ireland' for June of the present year.[1] Mr. Buick states that the ancient carn locally known as the Giant's Grave, situate at Loughloughan, in Co. Antrim, has recently been removed. It was a circular heap of stones 52 feet by 39 feet in diameter. 'Many years ago, but still in the recollection of old people in the neighbourhood, a large pillar stone stood upright upon it; it was usually spoken of as "the memorial stone." . . . The carn itself stood on the farm of Mr. William Hunter, and about three miles distant from the village of Broughshane. It occupied a commanding site at the head of a little ravine or dell overlooking the beautiful valley of the Braid. . . . The owner sold the stones of which it was composed to the Antrim Iron Ore Company, whose mines are close at hand, and who required them for road metalling and other purposes. His father had such a regard for the heap and such a superstitious fear of something dreadful happening if it were interfered with, that he would not allow the late Canon Grainger, though rector of the parish, to touch it when he sought permission to make a thorough examination of it. But *tempora mutantur*, &c. All the more reason for vigilance on the part of those who know the value of our ancient monuments and desire their preservation.'

Such is Mr. Buick's story of a recent case in this very part of Ireland. Unfortunately illness prevented him from being present at the destruction, and it was not till six weeks later that he was able to make any inquiry on the spot. He then found that three cists had been found in the cairn with remains of the skeletons and several fine urns of a most interesting type. These were saved, no doubt owing to the protection afforded them by the stone cists, and from the information supplied by the workmen an approximate plan of their position was made. But although these were saved who can say what was missed?

No better case could be brought forward of the deliberate destruction of prehistoric remains than this; and that such proceedings are not either uncommon or confined to any particular part of the British Islands is amply shown by the protest of the Dartmoor Committee. From the statements in this protest it would seem that the law actually aids and abets public officials in the systematic destruction of our prehistoric remains if by chance stone be used in their construction. Under an Act of William IV. the officer responsible for the maintenance of the highways is entitled to collect any stones on the surface of the adjoining land, public or private, for the purpose of being broken up to repair the roads. In such a locality as Dartmoor, covered with hut circles and the like, the mischief that may be done is great; while in many others it is scarcely less. What is to prevent the famous cup-marked stones of Ilkley from being so used, or even more conspicuous monuments like Stanton Drew and others? Is it possible to conceive of a situation more absurd than that shown by the existence in the same statute-book of two such Acts as the Ancient Monuments Act on the one hand and this mischievous Act on the other? The one rigidly protects the very same class of monuments that may be destroyed with impunity by virtue of the other. It is fortunate that the Dartmoor Committee has called special attention to this particular danger, and I can safely leave their memorial to speak for itself, as it is ably supported by societies and persons of influence.

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[1] Vol. xxxii. p. 163.

The danger to other remains, however, which may not be made of stones is equally great, though from other causes. The burial-mounds, mere heaps of earth that are spread more or less over the whole country, are constantly being destroyed, by accident or design, and their story is fully as important as that of any other class of prehistoric remains. The operations of agriculture are daily reducing such mounds to the general level of the surrounding land, and when the burial is at last exposed by the plough the relics are, in almost every case, scattered or destroyed, either in wanton mischief or from ignorance. It is a common thing for odds and ends from such sites to be brought to me at the British Museum, with the story that there was a great deal more found, but that they were divided among the farm hands or given to chance visitors.

That such a state of things should be general in this country is not creditable to our civilisation. Every modern state with any pretensions to culture takes pains to preserve the memorials of its past, and takes a legitimate pride in the preservation of its ancient monuments. In Britain we cannot claim the same glories of architecture of early times that are to be found in the Mediterranean area. Our modern history has its glories, architectural and of other kinds, but these may safely be left to the guardianship of public opinion. Public opinion, however, can scarcely be said to exist with regard to such of our monuments as are contemporary with the classical period of Greece. They are in the main neither generally known nor understood, and it cannot be said that they are immediately attractive. Nevertheless they are all we have to represent a page, or perhaps a volume, of our country's progress, and as such are deserving of attention and of preservation.

I ventured to urge some of these points in my Address to the Anthropological Section at Dover in 1899, and I then formulated a scheme that seemed to me practical and easy to work. I cannot do better now than repeat the words I used at that meeting. The plan I proposed was to enlist the active co-operation of the local archæological societies, each to take charge of the survey in its own area. Each society should record on the large scale Ordnance map every tumulus or earthwork within the county, and at the same time keep a register of the sites with numbers referring to the map, and in this register should be noted the names of the owner and tenant of the property, as well as any details which would be of use in exploring the tumuli. I am well aware that a survey of this kind has been begun by the Society of Antiquaries of London, and is still in progress; but this is of a far more comprehensive character, and is, moreover, primarily intended for publication. The more limited survey I now advocate would in no way interfere with it, but, on the contrary, would provide material for the other larger scheme. Once the local society is in possession of the necessary information just referred to, it would be the duty of its executive to exercise a beneficent control over any operations affecting the tumuli, and it may safely be said that such control could in no way be brought to bear so easily and effectively as through a local society.

Ireland is fortunate in having an admirable work devoted to its dolmens by the late Mr. Borlase. Such a record would form an excellent foundation for the survey as far as this special class of monument is concerned, and the survey of tumuli could be done concurrently. But both in Ireland and over the rest of the country a great deal has to be done and can only be accomplished by many and willing hands. If the plea that I now venture to make has the result of starting some such record I shall be content.

The Rev. J. O. Bevan was glad that the subject of the preservation and cataloguing of prehistoric and early historic remains had been dealt with by Mr. Read. Notwithstanding the limited number of scientific societies exclusively Irish, it was a matter for congratulation that the interesting and peculiar features of early Irish architecture and art had been so carefully conserved, owing to the exertion of public authorities. A great deal, however, remained to be done throughout the three kingdoms. It was monstrous, *e.g.*, that on such an important area as Dartmoor the highway authorities were permitted to appropriate valuable remains and break them up for the metalling of roads! Such an Act of Parliament ought to be at once rescinded. Public opinion should be roused in reference to the entire subject and Local Societies, such as those they represented, could do a great deal.[1]

At the conclusion of the Conference a hearty vote of thanks was accorded to the Chairman, on the motion of Mr. Mark Stirrup, seconded by Mr. F. W. Hembry.

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[1] The following resolutions were subsequently referred to the Council of the Association:—

'That the Council be requested to impress upon his Majesty's Government the desirability of appointing an Inspector of Ancient Monuments under the Ancient Monuments Act in the place of the late Lieut.-General Pitt-Rivers.

'That the Council be requested to call the attention of his Majesty's Government to the destruction of Ancient Monuments, especially on Dartmoor, which is authorised under the terms of the Highway Act, 5 & 6 Wm. IV., c. 50, the provisions of which are unrepealed by later Acts; and to urge the repeal of this section of the Act.'

The Corresponding Societies of the British Association for 1902–1903.

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Andersonian Naturalists' Society, 1885	Andersonian Nat. Soc.	204 George Street, Glasgow. R. Barnett Johnstone and R. McLean	231	None	2s. 6d.	Annals, occasionally.
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C.	Rev. W. W. Martin, Royal Literary and Scientific Institution, Bath	106	5s.	10s.	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, M.R.I.A.	243	None	1l. 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863	Belfast Nat. F. C.	Museum, College Square. J. St. J. Phillips and R. Patterson	320	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831	Berwicksh. Nat. Club	G. G. Butler, M.A., Ewart Park, Wooler, Northumberland	400	None	10s.	History of the Berwickshire Naturalists' Club, annually.
Birmingham and Midland Institute Scientific Society, 1859	Birm. & Mid. Inst. Sci. Soc.	Alfred Cresswell, Birm. and Midland Inst., Paradise Street, Birmingham	140	None	1l. 6s.	Records of Meteorological Observations, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Norwich Union Chambers, Congreve Street, Birmingham. W. P. Marshall	186	None	1l. 1s.	Proceedings, annually.
Brighton and Hove Natural History and Philosophical Society, 1854	Brighton N. H. Phil. Soc.	E. A. Pankhurst, 3 Clifton Road, Brighton	165	10s.	10s.	Report, annually.
Bristol Naturalists' Society, 1862	Bristol Nat. Soc.	S. H. Reynolds, M.A., University College, Bristol	139	5s.	10s.	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, F.I.C., 5 Chapel Street, Peterhead	170	7s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc.	R. L. Oswell, 5 Balmoral Road, Burton-on-Trent	210	None	5s.	Annual Report. Transactions occasionally.
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C.	H. E. Forrest, 37 Castle Street, Shrewsbury	183	5s.	5s.	Transactions and Record of Bare Facts, annually.
Chester Society of Natural Science, Literature, and Art, 1871	Chester Soc. Nat. Sci.	Grosvenor Museum, Chester. G. P. Miln and W. F. J. Shepheard	950	None	5s.	Report and Proceedings, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc.	The Museum, Public Buildings, Penzance. John B. Cornish	89	None	1l. 1s.	Report and Transactions, annually.
Croydon Microscopical and Natural History Club, 1870	Croydon M. N. H. C.	Public Hall, Croydon. G. W. Moore	230	None	10s.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C.	Dr. H. C. March, Portesham, Dorchester	330	None	10s.	Proceedings, annually.
Dublin Naturalists' Field Club, 1885	Dublin N. F. C.	H. J. Seymour, B.A., and W. B. Wright, B.A., 14 Hume Street, Dublin	152	5s.	5s.	'Irish Naturalist,' monthly; Report, annually.
East Kent Scientific and Natural History Society, 1857	E. Kent S. N. H. Soc.	A. Lander, The Medical Hall, Canterbury	109	None	10s.	Transactions, annually.
Eastbourne Natural History Society, 1867	Eastbourne N. H. Soc.	Dr. H. Habgood, Stafford House, Upperton Road, Eastbourne	100	2s. 6d.	7s. 6d.	Transactions, annually.
Edinburgh Geological Society, 1834	Edinb. Geol. Soc.	5 St. Andrew Square, Edinburgh. James Currie, M.A., F.R.S.E.	257	10s. 6d.	12s. 6d.	Transactions, annually.
Essex Field Club, 1880	Essex F. C.	William Cole, Springfield, Epping New Road, Buckhurst Hill, Essex	300	None	15s.	'Essex Naturalist,' quarterly; 'Special Memoirs,' occasionally; 'Museum Handbooks.'
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc.	J. Barclay Murdoch, Capelrig, Newton-Mearns, Glasgow	280	None	10s.	Transactions, annually.
Glasgow, Royal Philosophical Society of, 1802	Glasgow R. Phil. Soc.	Dr. Freeland Fergus, 207 Bath Street, Glasgow	1,080	1l. 1s.	1l. 1s.	Proceedings annually.

logical Society, 1886 . .						
Haslemere Microscope and Natural History Society	Haslemere Mic. N. H. Soc.	Rev. G. B. [illegible], [illegible], Hindhead, Surrey	—		2s.	
Hertfordshire Natural History Society and Field Club, 1875	Herts N. H. Soc. . .	A. E. Gibbs, F.L.S., St. Albans, and T. E. Lones, M.A., Rokeby Lodge, Watford	200	10s.	10s.	Transactions, occasionally.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C. .	C. E. Salmon, Clevelands, Reigate, and G. E. Frisby, Pengates Road, Redhill	87	10s.	10s. and 5s.	Proceedings, every two or three years.
Hull Geological Society, 1887 . .	Hull Geol. Soc. . .	W. S. Parrish, 3 Waltham Street, Hull	71	None	5s.	Transactions, annually.
Hull Scientific and Field Naturalists' Club, 1886	Hull Sci. F. N. C. .	T. Sheppard, F.G.S., The Museum, Hull	184	None	4s.	Transactions, annually.
Institution of Mining Engineers .	Inst. Min. Eng. . .	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	2,600	None	None	Transactions, monthly.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc. .	E. G. Critchley, 29 High Street, Inverness	190	None	5s.	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland .	J. Pim, W. Lawson, and C. H. Oldham, 35 Molesworth Street, Dublin	100	None	1l.	Journal, annually.
Leeds Geological Association, 1873	Leeds Geol. Assoc. .	Philosophical Hall, Leeds. Walter Parsons	80	None	5s.	Transactions, occasionally.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	W. M. Rankin, B.Sc., Cockburn Higher Grade School, Leeds	110	None	6s.	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	Corporation Museum. Herbert Ellis	332 Membs. & Associates	None	Members 1l. 1s.; Associates 10s. 6d.	Transactions, quarterly.
Liverpool Engineering Society, 1875	Liverpool E. Soc. . .	R. C. F. Annett, 4 Buckingham Avenue, Sefton Park, Liverpool	483	None	Resident 1l. 1s. Non-Res. and Students 10s. 6d.	Transactions, annually.
Liverpool Geographical Society, 1891	Liverpool Geog. Soc. .	Capt. E. C. Dubois Phillips, R.N., 14 Hargreave's Buildings, Chapel Street, Liverpool	730	None	Members 1l. 1s. Associates 10s. 6d.	Transactions and Report, annually.
Liverpool Geological Society, 1858 .	Liverpool Geol. Soc. .	Royal Institution. H. C. Beasley	58	None	21s.	Proceedings, annually.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M. C. Kermode, Cooil-ny-Feeaey, Ramsey, Isle of Man	148	2s. 6d.	Gentlemen 7s. 6d. Ladies and Non-Residents 5s.	Yn Lioar Manninagh, biennially.
Manchester Geographical Society, 1884	Manch. Geog. Soc. .	Eli Sowerbutts, F.R.G.S., 16 St. Mary's Parsonage, Manchester	860	None	Members 1l. 1s.; Associates 10s. 6d.	Journal, quarterly; 'Geography,' monthly.
Manchester Geological Society, 1838	Manch. Geol. Soc. .	5 John Dalton Street, Manchester. W. Saint and J. Tonge, jun.	235	None	1l.	Transactions, monthly.
Manchester Microscopical Society, 1880	Manch. Mic. Soc. .	E. C. Stump, 16 Herbert Street, Moss Side, and Charles Knight, 123 Oxford Street, Manchester	185	5s.	6s.	Transactions and Report, annually.
Manchester Statistical Society, 1833	Manch. Stat. Soc. . .	63 Brown Street, Manchester. F. E. M. Beardsall	210	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick .	320	1s. 6d.	3s. and 5s.	Report, annually.
Midland Counties Institution of Engineers, 1871	Mid. Count. Inst. . .	Stephenson Memorial Hall. G. Alfred Lewis, Albert Street, Derby	400	1l. 1s. None	Members 31s. 6d.; Associates and Students 20s.	Transactions of Institution of Mining Engineers, monthly.
Midland Institute of Mining, Civil, and Mechanical Engineers, 1869	Midland Inst. Eng. .	T. W. H. Mitchell, Mining Offices, Regent Street, Barnsley	290	None	1l. 10s.	Transactions of Inst. of Mining Engineers, monthly.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc. .	W. A. Nicholson, St. Helen's Square, Norwich	258	None	5s.	Transactions, annually.

CORRESPONDING SOCIETIES, &c. (*continued*).

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	1,250	None	25*s.* and 42*s.*	Transactions of Inst. of Mining Engineers, monthly.
North Staffordshire Field Club	N. Staff. F. C.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs; W. Wells Bladen, Stone, Staffs	466	5*s.*	5*s.*	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	Northants N. H. Soc.	H. N. Dixon, M.A., 23 East Park Parade, Northampton	180	None	10*s.*	Journal, quarterly.
Northumberland, Durham, and Newcastle-upon-Tyne, Natural History Society of	Northumb. N. H. Soc.	Hancock Museum, Newcastle-on-Tyne. A. H. Dickinson and Prof. M. C. Potter, M.A.	300	None	21*s.*	Transactions, annually.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Prof. J. W. Carr, M.A., University College, Nottingham	175	2*s.* 6*d.*	5*s.*	Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst.	J. Gardner, 3 County Place, Paisley	500	5*s.*	7*s.* 6*d.*	Report, annually; Meteorological Obs., occasionally.
Perthshire Soc. of Nat. Science, 1867	Perths. Soc. N. Sci.	Tay Street, Perth. S. T. Ellison	380	2*s.* 6*d.*	5*s.* 6*d.*	Trans. and Proc. annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, M.Sc., 105 Freehold Street, Rochdale	245	None	6*s.*	Transactions, biennially.
Rochester Naturalists' Club, 1878	Rochester N. C.	John Hepworth, Linden House, Rochester	154	None	5*s.*	'Rochester Naturalist,' quarterly.
Scotland, Mining Institute of, 1878	Mining Inst. Scot.	James Barrowman, Staneacre, Hamilton, N.B.	461	None	42*s.* and 25*s.*	Transactions of Inst. of Mining Engineers, monthly.
Somersetshire Archæological and Natural History Society, 1849	Som'setsh. A. N. H. Soc.	The Castle, Taunton. Lt.-Col. J. R. Bramble, Rev. F. W. Weaver and C. Tite	607	10*s.* 6*d.*	10*s.* 6*d.*	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc.	G. M. Clark, South African Museum, Cape Town	207	None	2*l.*	Transactions, occasionally.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union	George Abbott, M.R.C.S., 33 Upper Grosvenor Road, Tunbridge Wells	37 Societies	None	Minimum 5*s.*	'South-Eastern Naturalist,' annually.
South Staffordshire and East Worcestershire Institute of Mining Engineers, 1867	S. Staff. Inst. Eng.	Alexander Smith, M.Inst.C.E., 3 Newhall Street, Birmingham	179	1*l.* 1*s.* and 10*s.* 6*d.*	31*s.* 6*d.* and 21*s.*	Transactions of Institution of Mining Engineers, monthly.
Toronto, Astronomical Society of, 1884	Toronto Astr. Soc.	Canadian Institute Building. J. R. Collins	125	None	2 dollars	Transactions, annually.
Tyneside Geographical Society 1887	Tyneside Geog. Soc.	Geographical Institute, Barras Bridge, Newcastle-on-Tyne. Herbert Shaw, B.A., F.R.G.S.	1,200	None	10*s.* and 5*s.*	Journal, annually.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C.	Museum, Warwick. O. West, 31 Cherry Street, Coventry	109	2*s.* 6*d.*	5*s.*	Proceedings, annually.
West of Scotland, Marine Biological Association of the	W. Scot. Marine Biol. Assoc.	John A. Todd, 190 West George Street, Glasgow	150	None	Minimum 1*l.* 1*s.*	Report, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C.	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	240	10*s.*	10*s.*	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, M.A., F.G.S., Hopton, Mirfield	185	None	13*s.*	Proceedings, annually.
Yorkshire Naturalists' Union, 1861	Yorks. Nat. Union	W. Denison Roebuck, F.L.S., 259 Hyde Park Road, Leeds; E. Hawkesworth, Hunslet, Leeds	406 and 2,599 Associates.	None	10*s.* 6*d.*	Transactions, annually; 'The Naturalist,' monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc.	Museum, York. Dr. Tempest Anderson and C. E. Elmhirst	420	None	2*l.*	Report, annually.

Catalogue of the more important Papers, and especially those referring to Local Scientific Investigations, published by the Corresponding Societies during the year ending May 31, 1902.

⁂ This catalogue contains only the titles of papers published in the volumes or parts of the publications of the Corresponding Societies sent to the Secretary of the Committee in accordance with Rule 2.

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

BIGG-WITHER, H. Notes on Detonators. 'Trans. Inst. Min. Eng.' XXI. 442–448. 1902.

BLACK, W. G. Table of Storm Waves and Winds. 'Journal Manch. Geog. Soc.' XVII. 189. 1902.

BLADEN, W. WELLS. Report of the Meteorological Section. 'Trans. N. Staff. F. C.' XXXVI. 98–101. 1902.

BROWN, J. Some Matters Electric. (Presidential Address.) 'Proc. Belfast Nat. Hist. Phil. Soc. 1900–1901,' 17–33. 1901.

BURTON-ON-TRENT NATURAL HISTORY AND ARCHÆOLOGICAL SOCIETY. Weather Reports for 1897, 1898, 1899. 'Trans. Burt. N. H. Arch. Soc.' IV. 149–154. 1901.

CAMPBELL-BAYARD, F. Meteorological Report for 1900. 'Trans. Croydon M. N. H. C. 1900–1901,' 56–60, and Appendices of Tables, 53 pp. 1901.

CARADOC AND SEVERN VALLEY FIELD CLUB. Meteorological Notes, 1901. 'Record of Bare Facts,' No. 11, 54–65. [1902.]

CHAMBERS, G. F. Total Eclipse of the Sun in 1900. 'South-Eastern Naturalist for 1900,' 41–43. 1901.

COLE, Rev. E. MAULE. Water-spouts on the Yorkshire Wolds. 'Trans. Hull Sci. F. N. C.' I. 225–228. 1901.

COLLINGWOOD, EDWARD J. Meteorological Record at Lilburn Tower for 1900. 'History Berwicksh. Nat. Club,' XVII. 315–316. 1900.

CRESSWELL, ALFRED. Records of Meteorological Observations taken at the Observatory of the Birmingham and Midland Institute, Edgbaston, 1901. 'Birm. and Mid. Inst. Sci. Soc.' 25 pp.

DENNING, W. F. The Planet Jupiter and his Markings. 'Trans. Toronto Astr. Soc.' XII. 31–34. 1902.

DIX, F. Nineteenth Century Rainfall. 'Trans. Norf. Norw. Nat. Soc.' VII. 260–261. 1901.

DUNLOP, JAMES S. The Non-Elastic Deformation of Copper Wire under various Stresses. 'Proc. Glasgow Phil. Soc.' XXXII. 31–47. 1901.

ELVINS, ANDREW. Notes on World Formation by Accretion. 'Trans. Toronto Astr. Soc.' XII. 30–31. 1902.

HARVEY, ARTHUR. The Sun. 'Trans. Toronto Astr. Soc.' XII. 18–29. 1902.

—— Synchronism of Northern and Southern Auroræ. 'Trans. Toronto Astr. Soc.' XII. 37–38. 1902.

HEYWOOD, H. Meteorological Observations in the Society's District, 1900. 'Trans. Cardiff Nat. Soc.' XXXIII. 1–19. 1902.

HOPKINSON, JOHN. Report on the Rainfall in Hertfordshire in the Year 1900. 'Trans. Herts N. H. Soc.' XI. 33–42. 1901.

—— Meteorological Observations taken in Hertfordshire in the Year 1900. 'Trans. Herts N. H. Soc.' XI. 65–74. 1902.

HULL, Prof. G. F. The Pressure of Light and its Application to Astronomical Problems. 'Trans. Toronto Astr. Soc.' XII. 123-130. 1902.

JOHNSON, R. C. Notes on Observations of Total Solar Eclipses, 1851-1900. 'Proc. Liverpool Lit. Phil. Soc.' LV. 103-114. 1901.

KAY, J. The Carbon Process of Picture Making. 'Trans. E. Kent S. N. H. Soc.' I. 6-7. 1901.

LAUDER, A. Telephotography. 'Trans. E. Kent S. N. H. Soc.' I. 16-21. 1901.

LUMSDEN, GEORGE E. The Threshold of a New Century. (Presidential Address.) 'Trans. Toronto Astr. Soc.' XII. 2-17. 1902.

MARKHAM, C. A. Meteorological Report—Observers' Notes. 'Journal Northants. N. H. Soc.' XI. 35-41, 83-88, 119-124, 135-140. 1901, 1902.

MAWLEY, EDWARD. Report on Phenological Phenomena observed in Hertfordshire during the Year 1900. 'Trans. Herts N. H. Soc.' XI. 53-59. 1901.

MEYRICK, E. Meteorological Observations, 1901. 'Report Marlb. Coll. N. H. Soc.' No. 50, 103-124. 1902.

MIALL, Prof. L. C. Dew-Ponds. 'Journal Northants. N. H. Soc.' XI. 18-22. 1901.

MILLER, A. F. Observations of Nova Persei. 'Trans. Toronto Astr. Soc.' XII. 106-118. 1902.

MOORE, A. W. Report of Meteorological Section [1900]. 'Yn Lioar Manninagh,' III. 619-621. 1902.

MORTON, Prof. W. B. Colour. 'Proc. Belfast Nat. Hist. Phil. Soc. 1900-1901,' 60-62. 1901.

MUSSON, W. B. Stellar Evolution. 'Trans. Toronto Astr. Soc.' XII. 88-95. 1902.

NEWSHOLME, ARTHUR. Meteorological Report. 'Rep. Brighton N. H. Phil. Soc. 1900-1901,' 46-47. 1901.

PLOWRIGHT, Dr. C. B. Solar Halo and Mock Sun. 'Trans. Norf. Norw. Nat. Soc.' VII. 174-177. 1901.

POPE, JOSEPH. Halley's Comet. 'Trans. Toronto Astr. Soc.' XII. 52-60. 1902.

PRESTON, A. W. Meteorological Notes, 1900. 'Trans. Norf. Norw. Nat. Soc.' VII. 204-211. 1901.

RIGDEN, BRIAN. Canterbury Weather, 1900-1901. 'Trans. E. Kent S. N. H. Soc.' I. 47. 1901.

RUSSELL, Hon. ROLLO. Forms of Moisture in the Atmosphere. 'South-Eastern Naturalist for 1901,' 16-30. 1901.

SAVILLE-KENT, W. Three-Colour Photography applied to the Correct Delineation of Natural History Subjects. 'Trans. Croydon M. N. H. C. 1900-1901,' 17-22. 1901.

SHARMAN, EDWARD. Rainfall at Croyland Abbey, Wellingborough, 1861-1900. 'Journal Northants N. H. Soc.' XI. 41-43. 1901.

STUPART, R. F. Sun Spots and Precipitation. 'Trans. Toronto Astr. Soc.' XII. 42-46. 1902.

THACKER, S. L. (S. Staff. Inst. Eng.). The Determination of the Calorific Power of Fuel. 'Trans. Inst. Min. Eng.' XXII. 75-82. 1901.

WEATHERBE, J. H. Paths of the Planets in the Sky. 'Trans. Toronto Astr. Soc.' XII. 39-42. 1902.

WHEELER, ARTHUR O. Notes on the Field-work of Photographic Surveying as applied in Canada. 'Trans. Inst. Min. Eng.' XXI. 418-435. 1902.

WHITELEY, J. Meteorological Table for the Year 1901 (Halifax). 'Halifax Naturalist,' VI. 126–127. 1902.

YORKSHIRE PHILOSOPHICAL SOCIETY. Meteorological Record for the Year 1901. 'Report Yorks. Phil. Soc. for 1901,' 16–21. 1902.

Section B.—CHEMISTRY.

DAVIDSON, J. R. Filtration of Water. 'Trans. Liverpool E. Soc.' XXII. 91–102. 1901.

DICKINSON, JOSEPH. Gravitation of Firedamp. 'Trans. Manch. Geol. Soc.' XXVII. 163–165. 1901.

GLAISTER, Prof. JOHN. Sewage Disposal and Sewage Purification: a Critical Study of the various Modes now in use from the Points of View of Applicability, Economy, and Efficiency. 'Proc. Glasgow Phil. Soc.' XXXII. 151–191. 1901.

KITSON, ARTHUR (Midland Inst. Eng.). The Kitson System of Petroleum Incandescent Light. 'Trans. Inst. Min. Eng.' XXII. 52–56. 1901.

MACKIE, Dr. Why is the Sea Salt? 'Trans. Inverness Sci. Soc.' V. 338–358. 1902.

PICKARD, Dr. ROBERT HOWSON. Formation of Amides from Aldehydes. 'Proc. Birm. N. H. Phil. Soc.' XI. 110–111. 1902.

PLOWRIGHT, Dr. C. B. Woad as a Blue Dye, with an Account of its Bibliography. 'Trans. Norf. Norw. Nat. Soc.' VII. 138–146. 1901.

SMITH, J. KENT (N. Staff. Inst. Eng.). Water-softening. 'Trans. Inst. Min. Eng.' XXI. 278–289. 1901.

SUTHERLAND, DUCHESS OF. Note on Vegetable Colouring-matters used as Dyeing Materials in the Scotch Highlands. 'Essex Naturalist,' XII. 45. 1901.

Section C.—GEOLOGY.

BAIRSTOW, U. Local Land Movements. 'Halifax Naturalist,' VI. 76–82, 101–105, 113–119. 1901, 1902.

BAKER, B. A. Celestine Deposits of the Bristol District. 'Proc. Bristol Nat. Soc.' IX. 161–165. 1902.

BALDWIN, W. On *Prestwichia rotundata* found at Sparth Bottoms, Rochdale, Lancashire. 'Trans. Manch. Geol. Soc.' XXVII. 149–154. 1901.

BARKE, F. Report of the Geological Section. 'Trans. N. Staff. F. C.' XXXVI. 75–76. 1902.

BARNES, J., and W. F. HOLROYD. Notes on a Fossil found in the Shales below Millstone Grit, Pule Hill, Marsden. 'Trans. Manch. Geol. Soc.' XXVII. 156–159. 1901.

BATES, J. I. Cambrian Rocks of Warwickshire. 'Proc. Warw. N. A. F. C., 1900,' 13–20. 1902 (?).

BEASLEY, HENRY C. Some recent Exposures of the Keuper Marls at Oxton, Cheshire. 'Proc. Liverpool Geol. Soc.' IX. 68–74. 1901.

—— Notes on Type Specimens of *Cheirotherium herculis* (Egerton). 'Proc. Liverpool Geol. Soc.' IX. 81. 1901.

——, J. LOMAS, T. M. READE, I. C. THOMPSON, and Prof. W. A. HERDMAN. The Museum Question. 'Proc. Liverpool Geol. Soc.' IX. XV.–XXXIV. 1901.

BROOM, Dr. R. On the Structure of the Palate in *Dicynodon*, and its Allies. 'Trans. S. African Phil. Soc.' XI. 169–176. 1901.

—— On *Ictidosuchus primævus*. 'Trans. S. African Phil. Soc.' XI. 177–184. 1901.

CADELL, HENRY M. The Oilshale-fields of the Lothians. 'Trans. Inst. Min. Eng.' XXII. 314–371. 1902.

—— The Carboniferous Limestone Coal-fields of West Lothian. 'Trans. Inst. Min. Eng.' XXII. 372–400. 1902.

CADMAN, JOHN (N. Staff. Inst. Eng.). The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field. 'Trans. Inst. Min. Eng.' XXII. 89–99. 1901.

—— On the Discovery of the Bassey Mine *Spirorbis* Limestone to the West of the Anticline of the North Staffordshire Coal-field. 'Trans. N. Staff. F. C.' XXXVI. 81–85. 1902.

CAIRNCROSS, J. M. (Mining Inst. Scot.). The South Lesmahagon Coal-field. 'Trans. Inst. Min. Eng.' XXI. 234–250. 1901.

CALLAWAY, Dr. C. A Sketch of the Archæan Geology of Anglesey. 'Proc. Liverpool Geol. Soc.' IX. 82–93. 1901.

CARADOC AND SEVERN VALLEY FIELD CLUB. Geological Notes, 1901. 'Record of Bare Facts,' No. 11, 48–53. [1902.]

CHAPMAN, FREDERICK. The Ancient Beaches of Brighton and their Microscopical Contents. 'Rep. Brighton N. H. Phil. Soc. 1900–1901,' 17–20. 1901.

—— Ostracoda from the *Chara*-Marl of Hitchin. 'Trans. Herts. N. H Soc.' XI. 60–62. 1901.

COATES, HENRY. The Progress of Geology during the Nineteenth Century. (Annual Address.) 'Proc. Perths. Soc. Nat. Sci.' III. lxxix.–xciv. 1901.

DAVID, W. The Position of and Method of Working Bath Stone in the Quarries of the Bath Stone Firms. 'Trans. Inst. Min. Eng.' XX. 495–499. 1902.

DICKINSON, JOSEPH. Lead Mining Districts of the North of England and Derbyshire. 'Trans. Manch. Geol. Soc.' XXVII. 218–265. 1902.

FOSTER, C. LE NEVE. The Experimental Elucidation of certain Vein Phenomena. 'Trans. Cornwall R. Geol. Soc.' XII. 475–482. 1902.

FOX, HOWARD. On the Distribution of Fossils on the North Coast of Cornwall, South of the Camel. 'Trans. Cornwall R. Geol. Soc.' XII. 535–545. 1902.

GOODCHILD, J. G. The Geology of Burnmouth, Berwickshire. 'History Berwicksh. Nat. Club,' XVII. 228–234. 1901.

HALSE, EDWARD (N. Eng. Inst.). Some Silver-bearing Veins of Mexico (continued). 'Trans. Inst. Min. Eng.' XXI. 198–213. 1901.

HERDMAN, Prof. W. A. The Geological Succession and the Origin of Man. (Presidential Address.) 'Proc. Liverpool Geol. Soc.' IX. 1–24. 1901.

HILL, J. B. The Plutonic and other Intrusive Rocks of West Cornwal in their relation to the Mineral Ores. 'Trans. Cornwall R. Geol. Soc.' XII. 546–615. 1902.

HIND, Dr. WHEELTON. A List of Localities where Fossils occur in the Pendleside Series of the Country round North Staffordshire. 'Trans. N. Staff. F. C.' XXXVI. 77–80. 1902.

—— (N. Staff. Inst. Eng.). The Sequence of the Carboniferous Rocks in North Staffordshire. 'Trans. Inst. Min. Eng.' XXII. 219–227. 1902.

HOLMES, T. V. Geological Notes on the New Reservoirs in the Valley of the Lea, near Walthamstow, Essex. 'Essex Naturalist,' XII. 1–16. 1901.

HOPKINSON, JOHN. List of Works on the Geology of Hertfordshire, 1884–1900. 'Trans. Herts. N. H. Soc.' XI. 87–104. 1902.

KENDALL, PERCY F., and J. H. HOWARTH. Additions to the Records of the Yorkshire Boulder Committee's Fourteenth Year's Report, 1899–1900. 'The Naturalist for 1901,' 217–218. 1901.

LAPWORTH, Prof. CHARLES (S. Staff. Inst. Eng.). (Presidential Address.) [Geology and Engineering.] 'Trans. Inst. Min. Eng.' XXII. 63–73. 1901.

LAURENCE, W. K. Saltford Slip. 'Trans. Inst. Min. Eng.' XX. 476. 1902.

LEES, F. ARNOLD. Wetherby revisited by the Yorkshire Naturalists. 'The Naturalist for 1891,' 325–332. 1901.

LOMAS, J. The Occurrence of Estheria and Plant Remains in the Keuper Marls at Oxton, Birkenhead. 'Proc. Liverpool Geol. Soc.' IX. 75–80. 1901.

—— On Pre-Glacial Land Surfaces near Prenton. 'Proc. Liverpool Geol. Soc.' IX. 94–100. 1901.

LONGE, F. D. On the Formation of Flints in Chalk. 'Trans. Norf. Norw. Nat. Soc.' VII. 148–155. 1901.

LOUIS, Prof. HENRY. Dolomite. 'Trans. Burt. N. H. Arch. Soc.' IV. 111–116. 1901.

—— (N. Eng. Inst.). Note on a Mineral Vein in Wearmouth Colliery. 'Trans. Inst. Min. Eng.' XXII. 127–129. 1901.

LOWE, HARFORD J. The Sequence of the Lizard Rocks. (Second Paper.) 'Trans. Cornwall R. Geol. Soc.' XII. 507–534. 1902.

McDAKIN, J. GORDON. Geological Report—Coast Erosion. 'Trans. E. Kent S. N. H. Soc.' I. 45. 1901.

MACKIE, Dr. The Sands and Sandstones of Eastern Moray. 'Trans. Inverness Sci. Soc.' V. 34–61. 1902.

—— The Felspars present in Sedimentary Rocks as Indicators of the Conditions of Contemporaneous Climate. 'Trans. Inverness Sci. Soc.' V. 197–255. 1902.

MACNAIR, PETER. On the Occurrence of a Zone of Annelid Burrows across the Southern Highlands of Scotland. 'Trans. Perths. Soc. Nat. Sci.' III. 131–150. 1901.

MANTLE, H. G. Transportation of Glacial Boulders from the Lake District to the North-West Coast. 'Proc. Birmingham N. H. Phil. Soc. XI. 94–109. 1902.

MEYRICK, E. Report of the Geological Section. 'Report Marlb. Coll. N. H. Soc.' No. 50, 75–81. 1902.

MOLENGRAAFF, Dr. G. A. F. (N. Eng. Inst.). Remarks on Mr. Wm. Taylor Heslop's Paper on 'The Coal-fields of Natal.' 'Trans. Inst. Min. Eng.' XXI. 215–219. 1901.

MORGAN, Prof. C. LLOYD. The Effects of Lateral Pressure in the Bristol District: an Estimate and a Suggestion. 'Proc. Bristol Nat. Soc.' IX. 148–151. 1902.

—— The River Avon Gorge. 'Trans. Inst. Min. Eng.' XX. 514–516. 1902.

MORGAN, J. The Structure and Growth of Corals. 'Trans. E. Kent S. N. H. Soc.' I. 7–13. 1901.

MORTON, G. H. Carboniferous Limestone, North-East of Anglesey. 'Proc. Liverpool Geol. Soc.' IX. 25–32. 1901.

MORTON, G. H. The Carboniferous Limestone of Anglesey and Carnarvonshire. 'Proc. Liverpool Geol. Soc.' IX. 32–35. 1901.

—— Carboniferous Limestone of the East of Anglesey. 'Proc. Liverpool Geol. Soc.' IX. 36–48. 1901.

—— The Carboniferous Limestone Fossils of North Wales. 'Proc. Liverpool Geol. Soc.' IX. 49–67. 1901.

OBALSKI, J. Mineral Resources of the Province of Quebec, Canada. 'Trans. Inst. Min. Eng.' XXII. 505–508. 1902.

O'SULLIVAN, C. The Dales of Derbyshire. 'Trans. Burt. N. H. Arch. Soc.' IV. 49–64. 1901.

PEARSON, HUGH (Mining Inst. Scot.). The Rand Conglomerates, Transvaal. 'Trans. Inst. Min. Eng.' XXII. 209–213. 1902.

POOLE, HENRY S. (N. Staff. Inst. Eng.). The Coal-fields of New Brunswick, Canada. 'Trans. Inst. Min. Eng.' XXIII. 40–47. 1902.

RAYNER, FRANK, and J. HAROLD HERBERT. The Scenery and Underground Waters of the Malham District (West Yorkshire). 'Trans. Nott. Nat. Soc. 1900–1901,' 34–40. 1901.

READE, T. MELLARD, and PHILIP HOLLAND. The Green Slates of the Lake District, with a Theory of Slate Structure and Slaty Cleavage. 'Proc. Liverpool Geol. Soc.' IX. 101–127. 1901.

REID, A. S. Note on some Crustacean Tracks from the Cairnies Quarry, Glenalmond. 'Proc. Perths. Soc. Nat. Sci.' III. xciv. 1901.

REID, CLEMENT. Further Note on the Palæolithic Deposits at Hitchin. 'Trans. Herts N. H. Soc.' XI. 63–64. 1901.

REID, D. J. The Inverness Section of the Aviemore Line. 'Trans. Inverness Sci. Soc.' V. 254–263. 1902.

—— Bore at Inverness. 'Trans. Inverness Sci. Soc.' V. 400–401. 1902.

SANDEMAN, J. J. Gold Mining in the Rossland District, British Columbia. 'Trans. Inst. Min. Eng.' XX. 401–403. 1901.

SAWYER, A. R. The Tarquah Goldfield, Gold Coast, West Africa. 'Trans. Inst. Min. Eng.' XXII. 402–417. 1902.

SEYMOUR, H. J. The Microscopical Minerals occurring in Sands. 'Proc. Belfast Nat. F. C.' IV. 600–601. 1901.

SHEPPARD, THOMAS. Bibliography: Geology and Palæontology, 1897–98. 'The Naturalist for 1901,' 305–324. 1901.

SIMPSON, WILLIAM. Glacial Drift Deposits at Mytholmroyd. 'Halifax Naturalist,' VI. 93–96. 1901.

SMITH, JOHN. The Drift of Glacial Deposits in Ayrshire. 'Trans. Inverness Sci. Soc.' V. 95–105. 1902.

SMITH, WILLIAM. The Buffelsdoorn and adjacent Districts of the Northern Klerksdorp Goldfields, Transvaal. 'Trans. Inst. Min. Eng.' XXII. 444–448. 1902.

STIRLING, JAMES. The Geological Ages of the Gold Deposits of Victoria. 'Trans. Inst. Min. Eng.' XX. 442–475. 1902.

STEAVENSON, A. L. (N. Eng. Inst.). The Carboniferous Limestone Quarries of Weardale. 'Trans. Inst. Min. Eng.' XXII. 115–123. 1901.

STOBBS, JOHN T. On the Occurrence of a New Marine Bed in the Coal Measures of North Staffordshire. 'Trans. N. Staff. F. C.' XXXVI. 86–89. 1902.

STOBBS, T. (N. Staff. Inst. Eng.). Recent Work in the Correlation of the Measures of the Pottery Coal-field of North Staffordshire, with Suggestions for further Development. 'Trans. Inst. Min. Eng.' XXII. 229–246. 1902.

Swanston, W. Notes on some Clay Concretions from the Connecticut Valley, U.S.A. 'Proc. Belfast Nat. Hist. Phil. Soc. 1900–1901,' 49–50. 1901.

Thompson, Beeby. A Record of Two Wells. 'Journal Northants. N. H. Soc.' xi. 68–76, 93–105. 1901.

Thompson, Miss S. M. On the supposed Occurrence of a Patch of White Lias or Rhaetic Rock on the Shore North of Macedon Point, Belfast Lough. 'Proc. Belfast Nat. F. C.' iv. 566–569. 1901.

Ussher, W. A. E. The Culm-measure Types of Great Britain. 'Trans. Min. Eng.' xx. 360–387. 1901.

Waddington, John. Yorkshire Naturalists at Wykeham, near Scarborough. 'The Naturalist for 1901,' 293–301. 1901.

Waldron, F. W. On the Appearance and Disappearance of a Mud Island at Walfish Bay. 'Trans. S. African Phil. Soc.' xi. 185–188. 1901.

Wallace, Thomas. Recent Geological Changes and the Culbin Sands. 'Trans. Inverness Sci. Soc.' v. 105–123. 1902.

Wallace, Thomas D. Geological Notes on Strathdearn and the Aviemore Railway. 'Trans. Inverness Sci. Soc.' v. 305–314. 1902.

Ward, John. On a Fragment of the Tusk of a Mammoth from Fenton, with Notes on Previous Discoveries of Mammalian Remains in North Staffordshire. 'Trans. N. Staff. F. C.' xxxvi. 90–93. 1902.

—— Additions to the Literature relating to the Geology, Mineralogy, and Palæontology of North Staffordshire (continued). 'Trans. N. Staff. F. C.' xxxvi. 94–97. 1902.

Whitaker, Wm. Some Notes on Surrey Science. (Presidential Address.) 'Trans. Croydon M. N. H. C. 1900–1901,' xlviii.–lix. 1901.

—— Some Surrey Wells. (Third Paper.) 'Trans. Croydon M. N. H. C. 1900–1901,' 30–50. 1901.

Wilson, the late Edward, and Prof. S. H. Reynolds. Uphill Bone-caves. 'Proc. Bristol Nat. Soc.' ix. 152–160. 1902.

Woodruffe-Peacock, Rev. E. A. Naturalists in South Lincolnshire. 'The Naturalist for 1901,' 261–265. 1901.

Wright, Joseph. Foraminifera of the Pleistocene Clay of Bovevagh, co. Derry. 'Proc. Belfast Nat. F. C.' iv. 603–605. 1901.

—— The Foraminifera of the Pleistocene Clay, Shellag. 'Yn Lioar Manninagh,' iii. 627–629. 1902.

Wright, W. B. The Glacial Origin of Glendoo. 'Irish Naturalist,' xi. 96–102. 1902.

Section D.—ZOOLOGY.

Backhouse, James. Preliminary Catalogue of the British Bird Collections in the Possession of the Yorkshire Philosophical Society. Part III. 'Report Yorks. Phil. Soc. for 1901,' 33–62. 1902.

Bird, Rev. M. C. H. Observations on the Viper (*Pelius berus*). 'Trans. Norf. Norw. Nat. Soc.' vii. 243–245. 1901.

Bostock, E. D. Report of the Entomological Section. 'Trans. N. Staff. F. C.' xxxvi. 69–72. 1902.

Boulenger, G. A. Presidential Address to the South-Eastern Union of Scientific Societies (The Progress of Herpetology). 'South-Eastern Naturalist for 1901,' 1–11. 1901.

BOYD, W. C. List of the Lepidoptera of Cheshunt and its Neighbourhood. 'Trans. Herts N. H. Soc.' XI. 75–86. 1902.

BURTON, F. M. Occurrence of the Osprey in Lincolnshire. 'The Naturalist for 1901,' 161–162. 1901.

CAMPBELL, Col. On Some Prison Birds. 'Trans. Perths. Soc. Nat. Sci.' III. 97–101. 1901.

CARADOC AND SEVERN VALLEY FIELD CLUB. Zoological Notes, 1901. 'Record of Bare Facts,' No. 11, 36–47. [1902.]

CLARKE, H. SHORTRIDGE. Locusts in the Isle of Man. 'Yn Lioar Manninagh,' III. 543–544. 1901.

—— Report of the Entomological Section [1900]. 'Yn Lioar Manninagh,' III. 616–619. 1902.

—— The Leaf-cutter Bee (*Apis Centuncularis*). 'Yn Lioar Manninagh,' III. 627. 1902.

CONNER, H. D. Salmon Fisheries in Ireland and the Report of the Irish Inland Fisheries Commission. 'Journal Stat. Soc. Ireland,' XI. 63–74. 1901.

CRELLIN, Miss A. M. Notes on the Tortoise at Orry's Dale. 'Yn Lioar Manninagh,' III. 515. 1901.

CRELLIN, JOHN C. Report of Zoological Section [1900]. 'Yn Lioar Manninagh,' III. 612–615. 1902.

CROSSMAN, ALAN F. Notes on Birds observed in Hertfordshire during the Year 1900. 'Trans. Herts N. H. Soc.' XI. 47–52. 1901.

CROWTHER, J. E. The Natural History of Tag Lock: I. The Vertebrates. 'Halifax Naturalist,' VI. 73–75. 1901; II. Fishes. Ib. 97–100.

CRUMP, W. B., and others. A Spring Diary, 1901. 'Halifax Naturalist,' VI. 45–47. 1901.

DAWSON, CHARLES. Discovery of a Mummied Toad in a Flint Nodule, found at Lewes, Sussex. 'Rep. Brighton N. H. Phil. Soc. 1900–1901,' 34–39. 1901.

DRANE, R. Olla podrida with Nescio quidquid Sauce. [Natural History Notes.] 'Trans. Cardiff Nat. Soc.' XXXIII. 59–70. 1902.

DUTHIE, Lieut.-Col. W. H. M. Gulls—the Links of Land and Sea 'Trans. Perths. Soc. Nat. Sci.' III. 105–110. 1901.

EVANS, ARTHUR H. Presidential Address. [The Migration of Birds.] 'History Berwicksh. Nat. Club,' XVII. 185–196. 1901.

EVANS, WILLIAM. A Preliminary List of Collembola and Thysanura. 'Trans. Perths. Soc. Nat. Sci.' III. 150–154. 1901.

GEORGE, C. F. Lincolnshire Water Mites: Third List. 'The Naturalist for 1902,' 13–14. 1902.

GIBBS, A. E. Notes on Lepidoptera observed in Hertfordshire during the Year 1900. 'Trans. Herts N. H. Soc.' XI. 43–45. 1901.

GIBBS, THOMAS. Yorkshire Naturalists' Union at Masham. 'The Naturalist for 1902,' 15–20. 1902.

GURNEY, J. H. Coot Shooting on Hickling Broad. 'Trans. Norf. Norw. Nat. Soc.' VII. 267–273. 1901.

GYNGELL, WALTER. A Naturalist's Holiday amongst the Cumberland Sandhills. 'The Naturalist for 1902,' 157–163. 1902.

HALIFAX SCIENTIFIC SOCIETY. Local Records in Natural History. 'Halifax Naturalist,' VI. 120–125. 1901.

HALLIDAY, EDWARD. Wingless Moths.—III. 'Halifax Naturalist,' VI. 87–88. 1901.

Harmer, Dr. Sidney F. Presidential Address. [The Study of the Natural History of Aquatic Invertebrates.] 'Trans. Norf. Norw. Nat. Soc.' vii. 115–137. 1901.

—— On some Markings on the Skin of a Dolphin (*Delphinus delphis*). 'Trans. Norf. Norw. Nat. Soc.' vii. 185–187. 1901.

Harrison, Rev. G. R. Some British Birds of Prey. 'Trans. Burt. N. H. Arch. Soc.' iv. 15–18. 1901.

Hickson, Prof. Sydney J. Fertilisation. (Presidential Address.) 'Trans. Manch. Mic. Soc. 1902,' 25–34. 1902.

Horsley, Stephen. The Place of Man in Nature's Scale of Life. (Presidential Address.) 'Trans. E. Kent S. N. H. Soc.' i. 1–6. 1901.

Howes, Prof. G. B. Recent Work on Molluscan Morphology (Abstract). 'Essex Naturalist,' xii. 46–47. 1901.

Hull, Rev. J. E. Spiders of Northumberland and Durham: Some Notes of Recent Captures. 'The Naturalist for 1901,' 365–368. 1901.

Hull, Wm. The Natural History of Northamptonshire. (Presidential Address.) 'Journal Northants. N. H. Soc.' xi. 10–12. 1901.

Hutchinson, Jonathan. The Influence of Use upon Structural Modifications. 'South-Eastern Naturalist for 1901,' 51–54. 1901.

Isle of Man Natural History and Antiquarian Society. Birds Observed in the Isle of Man, 1900. 'Yn Lioar Manninagh,' iii. 634–635. 1902.

Kane, W. F. de V. Recent Progress in Irish Natural History. (Presidential Address to Dublin N. F. C.) 'Irish Naturalist,' xi. 53–60. 1902.

Kermode, P. M. C. List of Birds of the Isle of Man, with Notes. 'Yn Lioar Manninagh,' iii. 516–543. 1901.

Kew, H. Wallis. Notes on the Weevil-Cocoons of the Figworts. 'The Naturalist for 1902,' 149–155. 1902.

—— Lincolnshire Pseudo-scorpions: with an Account of the Association of such Animals with other Anthropods. 'The Naturalist for 1901,' 193–215. 1901.

—— On the Pairing of *Limax maximus*. 'The Naturalist for 1901,' 241–254. 1901.

Latter, Oswald H. Cuckoos' Eggs. 'South-Eastern Naturalist for 1901,' 31–35. 1901.

Leach, Edward F. Some Notes on Badgers. 'Journal Northants. N. H. Soc.' xi. 107–111. 1901.

Lebour, Miss M. V. Marine Mollusca of Sandsend, Yorkshire. 'The Naturalist for 1902,' 171–176. 1902.

Lett, Canon W. H. The Occurrence of Natterer's Bat and the Whiskered Bat in Co. Down. 'Proc. Belfast Nat. F. C.' iv. 602–603. 1901.

Masefield, J. R. B. Report of the Zoological Section. 'Trans. N. Staff. F. C.' xxxvi. 40–46. 1902.

—— The Land and Fresh-water Mollusca of Staffordshire. 'Trans. N. Staff. F. C.' xxxvi. 47–64. 1902.

—— Rufous Variety (*Perdix montana*, Brisson) of the Common Partridge in Staffordshire. 'Trans. N. Staff. F. C.' xxxvi. 65–68. 1902.

Maudson, B. F. Notes on Coleoptera. 'Trans. E. Kent S. N. H. Soc.' 6. 1901.

MEYRICK, E. Report of the Entomological Section. 'Report Marlb. Coll. N. H. Soc.' No. 50, 45–74. 1902.

—— Ornithological List. 'Report Marlb. Coll. N. H. Soc.' No. 50, 82–85. 1902.

MORLEY, B. Notes on the Lepidoptera of Skelmanthorpe during 1901. 'The Naturalist for 1902,' 141–144. 1902.

NEWTON, Prof. On some Cranes' Bones found in Norfolk. 'Trans. Norf. Norw. Nat. Soc.' VII. 158–159. 1901.

NORMAN, Commander F. M. Note on an alleged Embedded Toad from a Quarry at Coldstream. 'History Berwicksh. Nat. Club,' XVII. 250–251. 1901.

OTWAY, A. LOFTUS. Irish Red Deer. 'Irish Naturalist,' X. 101–104. 1901.

PATON, CYRIL. Notes on a few British Guiana Birds. 'Yn Lioar Manninagh,' III. 561–564. 1901.

PATTERSON, A. Natural History Notes from Yarmouth, 1900–1901. 'Trans. Norf. Norw. Nat. Soc.' VII. 177–184. 1901.

PEACOCK, MAX. Mammalia of Bottesford Parish and the Neighbourhood. 'The Naturalist for 1901,' 165–172. 1901.

PÉRINGNEY, L. Descriptive Catalogue of the Coleoptera of South Africa (*Lucanidæ* and *Scarabæidæ*). 'Trans. S. African Phil. Soc.' XII. 563 pp. 1901.

PICKLES, HAROLD. Stray Bird Notes. 'Halifax Naturalist,' VI. 53–56, 105–107. 1901.

PORRITT, GEO. T. Contribution towards the Entomology of Ambleside. 'The Naturalist for 1902,' 3–4. 1902.

PROGER, T. W., and D. R. PATERSON. Ornithological Notes for 1901. 'Trans. Cardiff Nat. Soc.' XXXIII. 87–89. 1902.

RALFE, P. G. Some further Notes on Manx Birds. 'Yn Lioar Manninagh,' III. 544–551. 1901.

ROEBUCK, W. DENISON. List of Yorkshire and Lincolnshire Birds. 'The Naturalist for 1902,' 97–112. 1902.

SAUNDERS, SIBERT. Glimpses of Beauty in the Structure of Marine Organisms. 'Trans. E. Kent S. N. H. Soc.' I. 23–25. 1901.

—— Report on Marine Zoology of Whitstable Bay for the Year 1901. 'Trans. E. Kent S. N. H. Soc.' I. 45–46. 1901.

SHEPPARD, THOMAS. Yorkshire Naturalists at Brough. 'The Naturalist for 1901,' 219–229. 1901.

—— Notes on the Skeleton of Sibbald's Rorqual in the Hull Museum. 'The Naturalist for 1901,' 233–240. 1901.

SLATER, HENRY H. The Birds of Northamptonshire and Neighbourhood. 'Journal Northants. N. H. Soc.' XI. 57–63. 1901.

SMALL, F. A. Notes on Lepidoptera for 1901. 'Trans. E. Kent S. N. H. Soc.' I. 48. 1901.

SMITH, ARTHUR. Lincolnshire Spiders. 'The Naturalist for 1901,' 269–287. 1901.

SORBY, Dr. H. C. On the Variations in Numbers and Habitat of Marine Animals on the Coast of Essex during the last Ten or Twelve Years. 'Essex Naturalist,' XII. 17–23. 1901.

SOUTHWELL, THOMAS. On the Breeding of the Crane in East Anglia. 'Trans. Norf. Norw. Nat. Soc.' VII. 160–170. 1901.

—— Some Additions to the Norwich Castle Museum in 1900. 'Trans. Norf. Norw. Nat. Soc.' VII. 171–174. 1901.

STAINFORTH, T., and H. E. JOHNSON. Second List of Coleoptera occurring near Hull. 'Trans. Hull Sci. F. N. C.' I. 239–243. 1901.

STAWEL-STOYEL, A. Note on the Appearance of a Foreign Beetle (*Diaxenes dendrobii*) at Watford. 'Trans. Herts N. H. Soc.' XI. 46. 1901.

STORER, G. H. Notes on some of our British Mammals, with special reference to those found near Burton-on-Trent. 'Trans. Burt. N. H. Arch. Soc.' IV. 5–14. 1901.

—— Our British Song-Birds. 'Trans. Burt. N. H. Arch. Soc.' IV. 65–79. 1901.

TAYLOR, W. The Whales and Dolphins of the Moray Firth. 'Trans. Inverness Sci. Soc.' V. 236–241. 1902.

THOMPSON, ISAAC C. The Place of the Copepoda in Nature. 'Yn Lioar Manninagh,' III. 621–624. 1902.

TUCK, W. H. Aculeate Hymenoptera at Tostock, near Bury St. Edmunds. 'Trans. Norf. Norw. Nat. Soc.' VII. 156–157. 1901.

WALLACE, THOMAS D. The Wild Boar in Britain. 'Trans. Inverness Sci. Soc.' V. 296–305. 1902.

WHITAKER, ARTHUR. Larvæ of *Sphinx convolvuli* in Yorkshire. 'The Naturalist for 1901,' 289–290. 1901.

WHYTE, WILLIAM. Birds of the Riverside. 'Trans. Perths. Soc. Nat. Sci.' III. 110–116. 1901.

WIGG, J. T., and A. PATTERSON. Notes on the Herring Fishery of 1900. 'Trans. Norf. Norw. Nat. Soc.' VII. 262–266. 1901.

WOOD, Mrs. Homing Instincts of the Gull. 'History Berwicksh. Nat. Club,' XVII. 260. 1901.

WOODRUFFE-PEACOCK, Rev. E. A. Lincolnshire Naturalists at Torksey. 'The Naturalist for 1902,' 133–138. 1902.

—— Lincolnshire Naturalists at Revesby. 'The Naturalist for 1902,' 145–148. 1902.

Section E.—GEOGRAPHY.

BELLAMY, C. H. En Route to the Passion Play. 'Journal Manch. Geog. Soc.' XVII. 25–28. 1901.

BRICE, ARTHUR MONTEFIORE. The Great Siberian Railroad. 'Journal Manch. Geog. Soc.' XVII. 37–45. 1901.

BRUCE, WILLIAM S. Arctic and Antarctic [and Notice of proposed Scottish National Antarctic Expedition]. 'Proc. Glasgow Phil. Soc.' XXXII. 1–12. 1901.

FORDHAM, HERBERT GEORGE. Hertfordshire Maps: a Descriptive Catalogue of the Maps of the County, 1579–1900. Part I. 1579–1673. 'Trans. Herts N. H. Soc.' XI. 1–32. 1901.

GEDDES, Prof. PATRICK. Geography at the Paris Exhibition. 'Journal Manch. Geog. Soc.' XVII. 69–71. 1901.

GIBBONS, Major ST. HILL. Explorations in Marotseland and Neighbouring Regions. 'Journal Manch. Geog. Soc.' XVII. 29–32. 1901.

GULSTON, ARTHUR. Some Notes on the Baltic and Arctic Voyages of the ss. 'Ermack' in 1899. 'Journal Manch. Geog. Soc.' XVII. 165–180. 1902.

HEYWOOD, Rev. J. W. A Holiday in Japan. 'Journal Manch. Geog. Soc.' XVII. 124–132. 1901.

KENNEDY, A. J. The Island of Santa Catalina, California. 'Journal Manch. Geog. Soc.' XVII. 181–182. 1902.

KOETTLITZ, Dr. REGINALD. Polar Work: What it is, why it should be done, and what is still to be done there, &c. 'Journal Manch. Geog. Soc.' XVII. 89–110. 1901.

LEMAIRE, Capt. CHARLES. The Sources of the Congo. 'Trans. Liverpool Geog. Soc.' X. 28–29. 1902.

MILLIGAN, SEATON F. Scenery and Antiquities of Sligo, Connemara, and Clare. 'Proc. Belfast Nat. Hist. Phil. Soc. 1900–1901,' 63–79. 1901.

MORENO, Dr. FRANCISCO P. Scenery of Argentina. 'Trans. Liverpool Geog. Soc.' X. 30–46. 1902.

NEWBY, JOHN R. Iceland and the Icelanders. 'Journal Manch. Geog. Soc.' XVII. 46–63. 1901.

OSWELL, B. L. Notes on the River Trent at Burton. 'Trans. Burt. N. H. Arch. Soc.' IV. 107–110. 1901.

PAYNE, ALBERT E. Notes on Ecuador, South America. 'Trans. Perths. Soc. Nat. Sci.' III. 116–131. 1901.

SCLATER, W. L. Notes on the so-called 'Post-office Stone' and other Inscribed Stones preserved in the South African Museum and elsewhere. 'Trans. S. African Phil. Soc.' XI. 189–206. 1901.

STROMYER, C. E. A Conical Surface Equivalent Projection. 'Journal Manch. Geog. Soc.' XVII. 183–185. 1902.

WILSON, D. J. The Tourist Movement in Ireland. 'Journal Stat. Soc. Ireland,' XI. 56–63. 1901.

WOODS, LUKE H. Belgium: What it is like, the best way to see it, and how to get there. 'Journal Manch. Geog. Soc.' XVII. 1–15. 1901.

WRAGGE, CLEMENT. The Snowy Ranges of Australia, Mount Kosciusko and its Observatory. 'Journal Manch. Geog. Soc.' XVII. 111–123. 1901.

Section F.—ECONOMIC SCIENCE AND STATISTICS.

DAWSON, CHARLES. The Housing of the People, with special reference to Dublin. 'Journal Stat. Soc. Ireland,' XI. 45–56. 1901.

DEWSNUP, E. R. The Neglect of English Canals. 'Halifax Naturalist,' VI. 68–71. 1901.

GALLOWAY, JOHN. Trusts and Combinations. 'Proc. Glasgow Phil. Soc.' XXXII. 205–214. 1901.

HANNON, P. J. Educational Value of Co-operation among Irish Farmers. 'Journal Stat. Soc. Ireland,' XI. 12–22. 1901.

MACASSEY, LYNDEN. Irish Railways and the State. 'Proc. Belfast Nat. Hist. Phil. Soc. 1900–1901,' 55–57. 1901.

McMURTRIE, J. Notes on the Forest of Mendip, its Mining Customs and Ancient Laws. 'Trans. Inst. Min. Eng.' XX. 528–580. 1902.

MARR, Dr. HAMILTON C. The Story of the Insane—with special reference to Glasgow. 'Proc. Glasgow Phil. Soc.' XXXII. 215–234. 1901.

O'NEILL, Dr. HENRY. The Progress of Sanitary Science in Ireland. 'Journal Stat. Soc. Ireland,' XI. 35–45. 1901.

PEAKE, H. C. Opening Address. (Coal Supply, &c.) 'Trans. Inst. Min. Eng.' XXI. 306–312. 1901.

Stannell, Chas. A. The Financial Aspect of Parliamentary Private Bill Procedure. 'Journal Stat. Soc. Ireland,' xi. 28–35. 1901.

Todd, John A. Taxation of Land Values. (Second Paper.) 'Proc. Glasgow Phil. Soc.' xxxii. 192–204. 1901.

Section G.—Engineering.

Allen, George L. Brick-making. 'Trans. Inst. Min. Eng.' xxii. 418–441. 1902.

Anderson, J. Wemyss. Refrigeration. 'Trans. Liverpool E. Soc.' xxii. 120–134. 1901.

Aspinall, John A. F. Inaugural Address. [1900.] Transport of Goods. 'Trans. Liverpool E. Soc.' xxii. 1–10. 1901.

Barrowman, James (Mining Inst. Scot.). What is the least possible Waste in Working Coal. 'Trans. Inst. Min. Eng.' xxiii. 55–68. 1902.

Blackett, W. C. (N. Eng. Inst.). A Method of Socketing a Winding-rope and its Attachment to a Cage without the Use of Ordinary Chains. 'Trans. Inst. Min. Eng.' xxiii. 10–16. 1902.

Broom, Robert (Mining Inst. Scot.). Unwatering and Fitting a Lanarkshire Colliery with Modern Appliances. 'Trans. Inst. Min. Eng.' xxii. 159–166. 1901.

Brown, Edward (Midland Inst. Eng.). The B. C. B. Instantaneous Either-side Brake for Railway Wagons and Similar Vehicles. 'Trans. Inst. Min. Eng.' xxii. 46–49. 1901.

Cadman, John (N. Staff. Inst. Eng.). The Occurrence, Mode of Working, and Treatment of the Ironstones found in the North Staffordshire Coal-field. 'Trans. Inst. Min. Eng.' xxii. 100–111. 1901.

Charlton, William (S. Staff. Inst. Eng.). A Method of Working the Thick Coal-seam in Two Sections. 'Trans. Inst. Min. Eng.' xxi. 264–268. 1901.

Chester, E. D. The Imperfect Pulverisation of Rocks by means of Stamping, and Suggestions for its Improvement. 'Trans. Inst. Min. Eng.' xxii. 453–459. 1902.

Clarke, R. W. (Mid. Inst. Eng.). Coal-mining in India. 'Trans. Inst. Min. Eng.' xxii. 184–192. 1902.

Coke, G. E. (Mid. Count. Inst.). Presidential Address. 'Trans. Inst. Min. Eng.' xxii. 22–24. 1901.

Colley, John (N. Eng. Inst.). Mechanical Undercutting. 'Trans. Inst. Min. Eng.' xxii. 130–135. 1901.

De Grave, L. W. (Chesterf. Mid. Count. Inst.). Investigations into some Electric Accidents and the Means of Preventing them. 'Trans. Inst. Min. Eng.' xxi. 136–150. 1901.

Dickinson, Joseph. Prevention of Accidents by Falls of Roof and Sides in Coal-mines. 'Trans. Manch. Geol. Soc.' xxvii. 138–142. 1901.

Drew, Walter Newton (Midland Inst. Eng.). An Instrument for the Automatic Record of Winding Operations. 'Trans. Inst. Min. Eng.' xxii. 42–44. 1901.

Eissler, M. The Production of Copper and its Sources of Supply. 'Trans. Inst. Min. Eng.' xxi. 315–352. 1901.

Flinn, Hugo. The Coal-fields and other Industrial Resources of Ireland. 'Trans. Liverpool E. Soc.' xxii. 160–177. 1901.

FOWLER, A. F. Dredging on the River Ribble. 'Trans. Liverpool E. Soc.' XXII. 11–20. 1901.

FOWLER, G., and G. CARRINGTON (Chesterf. Mid. Count. Inst.). Systematic Timbering at the Babbington Collieries. 'Trans. Inst. Min. Eng.' XXI. 124–128. 1901.

GARFORTH, W. E. (Mid. Count. Inst.). Experimental Gallery for testing Life-saving Apparatus. 'Trans. Inst. Min. Eng.' XXII. 169–172. 1902.

GLASS, R. W. (N. Eng. Inst.). Endless-rope Haulage at Axwell Park Colliery. 'Trans. Inst. Min. Eng.' XXI. 167–172. 1901.

GLEDHILL, EDWARD. The Analogy between the Gold 'Cintas' of Colombia and the Auriferous Gravels of California. 'Trans. Inst. Min. Eng.' XX. 391–398. 1901.

GOULD, C. V. (N. Staff. Inst. Eng.). Fitting a new Drum-shaft to a Winding-engine, Florence Colliery, Longton. 'Trans. Inst. Min. Eng.' XXII. 250–254. 1902.

HALBAUM, H. W. G. The Theory of the Equivalent Orifice treated Graphically. 'Trans. Inst. Min. Eng.' XX. 404–417. 1901.

—— An Extension of the Equivalent-Orifice Theory. 'Trans. Inst. Min. Eng.' XXI. 355–367. 1902.

—— A new Diagram of the Work of Mine Ventilation. 'Trans. Inst. Min. Eng.' XXII. 484–492. 1902.

HANCOCK, H. LIPSON. Mining and Treatment of Copper Ore at the Wallaroo and Moonta Mines, South Australia. 'Trans. Inst. Min. Eng.' XXII. 461–483. 1902.

HOPE, ALARIC. Construction in Fortified Concrete. 'Trans. Liverpool E. Soc.' XXII. 61–77. 1901.

HOSKOLD, H. D. A New Civil and Mining Engineer's Transit Theodolite for connecting Underground Workings to the Surface, *vice versâ*, and for general Surveying. 'Trans. Inst. Min. Eng.' XXII. 536–555. 1902.

JONES, J. A. The Development and Working of Minerals in the Province of Leon, Spain. 'Trans. Inst. Min. Eng.' XX. 420–441. 1901.

KEIGHLEY, Fred. C. Coke-making at the Oliver Coke Works. 'Trans. Inst. Min. Eng.' XXII. 493–503. 1902.

KER, W. ARTHUR. The Electric Driving of Workshops. 'Trans. Liverpool E. Soc.' XXII. 31–50. 1901.

LEWIS, Sir W. T. Presidential Address. (Coal Mining.) 'Trans. Inst. Min. Eng.' XXII. 280–292. 1902.

LOUIS, Prof. HENRY (N. Eng. Inst.). Standardisation of Surveyors' Chains. 'Trans. Inst. Min. Eng.' XXIII. 85–90. 1902.

MACLAREN, J. MALCOLM. The Charters Towers Gold-field, Queensland. 'Trans. Inst. Min. Eng.' XXI. 379–401. 1902.

MCMURTRIE, GEORGE E. J. Methods of Working the Thin Coal-seams of the Bristol and Somerset field. 'Trans. Inst. Min. Eng.' XX. 340–357. 1901.

MEACHEM, F. G. (S. Staff. Inst. Eng.). Timbering in Mines. 'Trans. Inst. Min. Eng.' XXI. 304–305. 1901.

MORGANS, THOMAS. Notes on the Lead Industry of the Mendip Hills. 'Trans. Inst. Min. Eng.' XX. 478–494. 1902.

O'BRIEN, H. E., and B. HUMPHREY. Springs. 'Trans. Liverpool E. Soc.' XXII. 183–200. 1901.

PILKINGTON, HERBERT (Chesterf. Mid. Count. Inst.). Blast Furnace Fuels. 'Trans. Inst. Min. Eng.' XXI. 155–166. 1901.

Reid, Alexander (Midland Inst. Eng.). Chinese Mines and Miners. 'Trans. Inst. Min. Eng.' xxiii. 26–37. 1902.

Reumaux, E. Use of Waste-gases from Bye-product Coke-ovens in Explosion-motors. 'Trans. Inst. Min. Eng.' xxi. 402–405. 1902.

Short, Prof. Sidney H. Tramway Motors. 'Trans. Liverpool E. Soc.' xxii. 143–153. 1901.

Swann, Hugh P. (Mining Inst. Scot.). The Practical Results obtained on Changing the Motive Power of an Underground Pump from Steam to Electricity. 'Trans. Inst. Min. Eng.' xxii. 214–217. 1902.

Thompson, G. R. The Connection of Underground and Surface Surveys. 'Trans. Inst. Min. Eng.' xxii. 519–585. 1902.

Verschoyle, W. Denham. Gold Dredging. 'Trans. Inst. Min. Eng.' xxi. 372–378. 1902.

Von Sobbe, F. A. Mining and Treatment of Diamond-bearing Ground. 'Trans. Liverpool E. Soc.' xxii. 108–115. 1901.

Welton, William S. (N. Eng. Inst.). Auriferous Gravels and Hydraulic Mining. 'Trans. Inst. Min. Eng.' xxii. 137–151. 1901.

Wilson, W. B., jun. (N. Eng. Inst.). Tapping Drowned Workings at Wheatley Hill Colliery. 'Trans. Inst. Min. Eng.' xxiii. 72–81. 1902.

Winder, Oliver. The Design of Underframes and Bogies for Rolling Stock. 'Trans. Liverpool E. Soc.' xxii. 206–223. 1901.

Wood, W. O. (N. Eng. Inst.). The Sussman Electric Miners' Lamp. 'Trans. Inst. Min. Eng.' xxi. 189–194. 1901.

Section H.—ANTHROPOLOGY.

Barns, Rev. Thomas. The *Limes* Britannicus. 'Trans. N. Staffs. F. C.' xxxvi. 105–128. 1902.

Campbell, Duncan. Highland Sheilings in the Olden Time. 'Trans. Inverness Sci. Soc.' v. 62–90. 1902.

Collyer, H. C. The Stone Monuments of Brittany. 'Trans. Croydon M. N. H. C. 1900–1901,' 22–29. 1901.

Crellin, Miss A. M. Report of the Anthropological Section (Folklore) [1900]. 'Yn Lioar Manninagh,' iii. 610–611. 1902.

Cursitor, James. The Scottish Brochs, their Age and their Destruction. 'Trans. Inverness Sci. Soc.' v. 225–226. 1902.

Dixon, S. B. On Palæolithic Flint Implements found at Knowle, near Savernake Forest. 'Report Marlb. Coll. N. H. Soc.' No. 50, 29–34. 1902.

Fraser, Rev. Donald. The Zulu of Nyasaland: their Manners and Customs. 'Proc. Glasgow Phil. Soc.' xxxii. 60–75. 1901.

Gaythorpe, Harper. Notes on a Socketed Bronze Celt. 'Proc. Bath N. H. A. F. C.' ix. 294–300. 1901.

Gray, H. St. George. Bronze Sword found on Pitney Moor, Somerset. 'Proc. Somersetsh. A. N. H. Soc.' 230–233. 1902.

Greswell, Rev. W. Ancient Dumnonia. 'Proc. Somersetsh. A. N. H. Soc.' xlvii. 175–188. 1902.

Johnson, J. P. Palæolithic Implements from the Low-Level Drift of the Thames Valley. 'Essex Naturalist,' xii. 52–57. 1901.

Kermode, P. M. C. Early Lamps and Candle-holders in the Isle of Man. 'Yn Lioar Manninagh,' iii. 570–574. 1901.

KERMODE, P. M. C. Report of the Archæological Section [1900]. 'Yn Lioar Manninagh,' III. 607-610. 1902.

—— Sculptured and Inscribed Stones recently found at Kirk Maughold. 'Yn Lioar Manninagh,' III. 629-633. 1902.

LITTLER, H. W. Notes on the Hand-printing Silk Works at Waltham Abbey and West Ham. 'Essex Naturalist,' XII. 43-44. 1901.

LOVETT, EDWARD. Fish-hooks or Gorges of Wood from France (similar to those from Essex). 'Essex Naturalist,' XII. 28-31. 1901.

MATTHEWS, J. HOBSON. The Place-names of the Cardiff District. 'Trans. Cardiff Nat. Soc.' XXXIII. 33-46. 1902.

MEYRICK, E. Anthropometrical Report. 'Rep. Marlb. Coll. N. H. Soc.' No. 50, 125-150. 1902.

MORGAN, Prof. C. LLOYD. Burwalls and Stokeleigh Camps. 'Proc. Somersetsh. A. N. H. Soc.' XLVII. 217-229. 1902.

MULQUEEN, Mr. Round Towers and Brochs. 'Trans. Inverness Sci. Soc.' V. 242-245. 1902.

NORTHAMPTONSHIRE NATURAL HISTORY SOCIETY. Report on Prehistoric Remains. 'Journal Northants. N. H. Soc.' XI. 8-9. 1901.

PATTERSON, W. H. Some Account of the Objects comprised in Lord Deramore's Recent Donation [to the Society's Museum]. 'Proc. Belfast Nat. Hist. Phil. Soc. 1900-1901,' 43-48. 1901.

RATCLIFFE, J. L. On Plato's Communistic Theory. 'Proc. Liverpool Lit. Phil. Soc.' LV. 115-132. 1901.

ROBARTS, N. F. Stone and Bronze Celts Recently Discovered in Croydon and Neighbourhood. 'Trans. Croydon M. N. H. C. 1900-1901,' 51-56. 1901.

ROSS, Dr. ALEXANDER. Brochs: What are they? 'Trans. Inverness Sci. Soc.' V. 325-337. 1902.

ROSS, Dr. JOHN. The Chinese People and their Religions. 'Proc. Glasgow Phil. Soc.' XXXII. 48-59. 1901.

ROTH, H. LING. Bankfield Museum Notes. II.—The Burmese Collection. 'Halifax Naturalist,' VI. 29-38, 61-64. 1901; III.—An Hawaian Leglet. 'Halifax Naturalist,' VI. 83-86. 1901.

SWINNERTON, FREDERICK. Neolithic 'Fire-holes' or Outside Cooking Places. 'Yn Lioar Manninagh,' III. 570. 1901.

—— Finds in Rushen's Pre-historic Remains. 'Yn Lioar Manninagh,' III. 635-646. 1902.

TOMS, H. S. The Pottery of Pre-historic and Roman Britain. 'Rep. Brighton N. H. Phil. Soc. 1900-1901,' 22-33. 1901.

VINYCOMB, JOHN. Symbolic Ideas of the Ancients concerning Trees and Plants. 'Proc. Belfast Nat. F. C.' IV. 591-596. 1901.

WALLACE, THOMAS D. The Men of the Ice Age. 'Trans. Inverness Sci. Soc.' V. 135-136. 1902.

—— The Mound Builders of America. (Retiring Address, 1896.) 'Trans. Inverness Sci. Soc.' V. 136-138. 1902.

—— Pre-Glacial Man. 'Trans. Inverness Sci. Soc.' V. 315-325. 1902.

WOOD, G. W. Lhuyd's 'Archæologia' and the Manx Language. 'Yn Lioar Manninagh,' III. 565-569. 1901.

Section I.—PHYSIOLOGY.

GALT, Prof. HUGH. Some Points in the Analysis of Meat Extracts and Allied Preparations, with Notes on their Dietetic Value. 'Proc. Glasgow Phil. Soc.' XXXII. 19–30. 1901.

GREEN, R. F. The Problem of Consciousness. 'Proc. Liverpool Lit. Phil. Soc.' LV. 133–155. 1901.

LEVICK, JOHN. The Rôle of Mosquitos in the Spread of Malaria. 'Proc. Birm. N. H. Phil. Soc.' XI. 69–63. 1902.

LONG, SYDNEY H. The Mosquito-Malaria Theory. 'Trans. Norf. Norw. Nat. Soc.' VII. 188–204. 1901.

RANSOM, Dr. W. B. The *Vis medicatrix naturæ.* (Presidential Address.) 'Trans. Nott. Nat. Soc. 1900–1901,' 19–33. 1901.

Section K.—BOTANY.

BENNETT, ARTHUR. *Peucedanum* palustre in Lake Lancashire. 'The Naturalist for 1901,' 267–268. 1901.

BLOOMFIELD, Rev. E. N. A List of Suffolk Mosses. 'Trans. Norf. Norw. Nat. Soc.' VII. 227–242. 1901.

BRETT, CYRIL. List of late Flowering Plants at Alton. 'Trans. N. Staff. F. C.' XXXVI. 73–74. 1902.

BURRELL, W. H. On the Occurrence of *Æcidium clatinum* in Norfolk. 'Trans. Norf. Norw. Nat. Soc.' VII. 255–259. 1901.

BURTON-ON-TRENT NATURAL HISTORY AND ARCHÆOLOGICAL SOCIETY (Botanical Section). The Flora of Burton-on-Trent and Neighbourhood. Part IV. Conclusion of the Dicotyledons, the Monocotyledons, Cryptogamia, and Characeæ. 'Trans. Burt. N. H. Arch. Soc.' IV. 117–148. 1901.

CARADOC AND SEVERN VALLEY FIELD CLUB. Botanical Notes, 1901. 'Record of Bare Facts,' No. 11, 5–35. [1902.]

CORBETT, HERBERT H. Yorkshire Naturalists at Conisborough and Doncaster. 'The Naturalist for 1902,' 117–124. 1902.

CROSSLAND, CHARLES. The Collecting, Drying, and Mounting of Plants for the Herbarium. 'Halifax Naturalist,' VI. 39–44. 1901.

—— Tree-destroying Fungi. 'Halifax Naturalist,' VI. 108–109. 1901.

—— *Mollisia cinerascens*, Rehm, at Brough; a new Record for Great Britain. 'Trans. Hull Sci. F. N. C.' I. 244. 1901.

—— Fungus Foray at Cadeby, Melton, Sprotborough, and Warmsworth. 'The Naturalist for 1901,' 337–350. 1901.

—— Fungi at Masham and Swinton. 'The Naturalist for 1902,' 21–31. 1902.

CRUMP, W. B. The Flora of the Parish of Halifax. 'Halifax Naturalist,' VI. App. xlix.–lxiv. 1901.

——, and W. G. SMITH. The Utilisation of Waterworks' Gathering Grounds by Afforestation. 'Halifax Naturalist,' VII. 1–8. 1902.

DAVIES, JOHN H. The Botany of the Shores of Lough Neagh. 'Proc. Belfast Nat. Hist. Phil. Soc. 1900–1901,' 35–40. 1901.

DIXON, H. N. Phenological Observations, 1898, 1899, 1900. 'Journal Northants. N. H. Soc.' XI. 112–116. 1901.

—— Botanical Notes. 'Journal Northants. N. H. Soc.' XI. 117. 1901.

—— A Preliminary List of Norfolk Mosses. 'Trans. Norf. Norw. Nat. Soc.' 212–226. 1901.

Druce, G. Claridge. Notes on the Northamptonshire Flora. 'Journal Northants N. H. Soc.' xi. 13–17. 1901.

Dunn, S. T. Origin of the Dead-nettles in Britain. 'South-Eastern Naturalist for 1901,' 16–40. 1901.

Friend, Rev. Hilderic. Some Lakeland Host-Plants and Parasites. 'The Naturalist for 1901,' 173–176. 1901.

Grant, C. H. B. List of Mosses from Isle of Man, December 1900. 'Yn Lioar Manninagh,' iii. 633–634. 1902.

Halstead, T. The Natural History of Tag Lock: III.—Flowering Plants. 'Halifax Naturalist,' vii. 13–16. 1902.

Ingham, William. Harpidioid Hypna of Yorkshire and Durham. 'The Naturalist for 1902,' 93–96. 1902.

Keegan, Dr. P. Q. The Chemistry of some Common Plants. 'The Naturalist for 1902,' 165–169. 1902.

Kermode, Rev. S. A. P. Retiring Address. (The Work of the Isle of Man Natural History and Antiquarian Society.) 'Yn Lioar Manninagh,' iii. 604–607. 1902.

—— Report of Botanical Section [1900]. 'Yn Lioar Manninagh,' iii. 611–612. 1902.

Larder, J. Lincolnshire Freshwater Algæ. 'The Naturalist for 1902,' 59–61. 1902.

Leach, R. E. Some Westmorland Plants. 'The Naturalist for 1902,' 155–156. 1902.

Lees, F. Arnold. Some Flower Features of the Southern Ainsty. 'The Naturalist for 1902,' 63–64. 1902.

Leslie, J. History and Culture of the Grape Vine. 'Trans. Perths. Soc. Nat. Sci.' iii. 101–105. 1901.

MacLay, Prof. A. Technical Colleges in Germany and in Glasgow. 'Proc. Glasgow Phil. Soc.' xxxii. 76–110. 1901.

Marloth, Dr. R. Notes on the Occurrence of Alpine Types in the Vegetation of the Higher Peaks of the South-Western Region of the Cape. 'Trans. S. African Phil. Soc.' xi. 161–168. 1901.

Massee, George. Coprophilous Fungi. Abstract of Address delivered at Cadeby, September 23, 1901, at the Yorkshire Fungus Foray. 'The Naturalist for 1901,' 333–336. 1901.

——, and Charles Crossland. New British Discomycetes.—Part I. 'The Naturalist for 1901,' 177–189. 1901.

—— —— New Yorkshire Agarics. 'The Naturalist for 1902,' 1–2. 1902.

Meyrick, E. Report of the Botanical Section. 'Report Marlb. Coll. N. H. Soc.' No. 50, 35–44. 1902.

Mills, F. W., and R. H. Philip. The Diatomaceæ of the Hull District. 'Trans. Hull Sci. F. N. C.' i. 157–224. 1901.

O'Sullivan, James. A Glimpse of the Life of Chlorophyllous Plants. [Presidential Address.] 'Trans. Burt. N. H. Arch. Soc.' iv. 82–89. 1901.

Painter, Rev. W. H. Additional Notes to the Flora of Derbyshire. 'The Naturalist for 1902,' 5–12. 1902.

Petch, T. The Sea Lavender (*Statice limonium*) in Holderness. 'Trans. Hull Sci. F. N. C.' i. 233–235. 1901.

—— *Paludestrina jenkinsi* near Hull. 'Trans. Hull Sci. F. N. C.' i. 236–237. 1901.

Petty, S. Lister. Some Plants of Silverdale, West Lancashire. 'The Naturalist for 1902,' 33–54. 1902.

PHILLIPS, W. H. My Hobby about Ferns and its Results. 'Belfast Nat. F. C.' IV. 605-624. 1901.

PRAEGER, R. LLOYD. Botanising in the Centre and West of Ireland. 'Proc. Belfast Nat. F. C.' IV. 563-565. 1901.

—— Additions to 'Irish Topographical Botany' in 1901. 'Irish Naturalist,' XI. 1-8. 1902.

READER, Rev. P. H. Notes on a Collection of Lichens by the late J. Hardy. 'History Berwicksh. Nat. Club,' XVII. 261-264. 1901.

SARGANT, Miss ETHEL. The Adaptation of Seedlings to their Surroundings. 'South-Eastern Naturalist for 1901,' 12-15. 1901.

SCRIVEN, R. G. Some Observations on the Growth of Trees of various Ages. 'Journal Northants. N. H. Soc.' XI. 125-130. 1902.

SHOOSMITH, W. B. The Diatomaceæ. 'Journal Northants. N. H. Soc.' XI. 64-67. 1901.

SOUTHWELL, THOMAS. On Mr. Marsham's 'Indications of Spring.' 'Trans. Norf. Norw. Nat. Soc.' VII. 246-254. 1901.

STOW, Miss S. C. List of Lincolnshire Hepatics. 'The Naturalist for 1902,' 55-58. 1902.

STUART, Dr. CHARLES. The Changes which take place in Plants in a Wild and Cultivated State. 'History Berwicksh. Nat. Club,' XVII. 275-282. 1901.

WADDELL, Rev. C. H. Presidential Address. (The Work of the Club.) 'Proc. Belfast Nat. F. C.' IV. 549-559. 1901.

WEST, W. and G. S. The Alga-Flora of Yorkshire. 'Trans. Yorks. Nat. Union,' Part 25, pp. 101-164. 1901.

WHELDON, J. A. The North of England Harpidia (after Renauld). 'The Naturalist for 1902,' 65-92. 1902.

——, and ALBERT WILSON. Notes on the Flora of Over Wyresdale. 'The Naturalist for 1901,' 357-362. 1901.

WHITE, JAMES W. Bristol Field Botany in 1901. 'Proc. Bristol Nat. Soc.' IX. 123-147. 1902.

WILKINSON, HENRY J. Catalogue of British Plants in the Herbarium of the Yorkshire Philosophical Society.—Part VIII. 'Report Yorks. Phil. Soc. for 1901,' 63-78. 1902.

WILSON, ALBERT. The Great Smoke-cloud of the North of England and its Influence on Plants. 'Halifax Naturalist,' VI. 57-61. 1901.

Section L.—EDUCATIONAL SCIENCE.

BUCKTON, Miss A. Nature Knowledge for Elementary Schools. 'South-Eastern Naturalist for 1901,' 44.

OLDHAM, C. H. The Bearing on Industry of the Impending Changes in Irish Education. 'Journal Stat. Soc. Ireland,' XI. 1-12. 1901.

OBITUARY.

ARMSTRONG, Lord. By Principal H. Palin Gurney (N. Eng. Inst.). 'Trans. Inst. Min. Eng.' XXI. 176-188. 1901.

BIDGOOD, WILLIAM. By C. T. 'Proc. Somersetsh. A. N. H. Soc.' XLVII. 234-236. 1902.

CROSSMAN, Major-Gen. Sir WILLIAM. By Sir George B. Douglas. 'History Berwicksh. Nat. Club,' XVII. 313–314. 1901.

FORSTER, GEORGE BAKER. By R. H. Forster. 'Trans. Inst. Min. Eng.' XXIII. 3–9. 1902.

GREENWELL, GEORGE CLEMENTSON. By G. C. Greenwell. 'Trans. Inst. Min. Eng.' XXII. 124–126. 1901.

HAWORTH, ADRIAN HARDY. By T. S[heppard]. 'Trans. Hull Sci. F. N. C.' I. 229–232. 1901.

HODGSON, WILLIAM. By William Thomson. 'The Naturalist for 1901,' 261–265. 1901.

JEFFCOCK, THOMAS WILLIAM. By Oscar J. Cotterell. 'Trans. Inst. Min. Eng.' XXII. 57. 1901.

PERCY, R. F. (Mid. Count. Inst.). The Belvoir Iron-ore. 'Trans. Inst. Min. Eng.' XXII. 30–34. 1901.

PITT-RIVERS, General. By H. St. George Gray. 'Proc. Somersetsh. A. N. H. Soc.' XLVII. 123–137. 1902.

SYMONS, GEORGE JAMES. By W. Cole. 'Essex Naturalist,' XII. 57–60. 1901.

WEST, WILLIAM, jun. By W. D. R[oebuck]. 'The Naturalist for 1901,' 303–304. 1901.

WILSON, TOM HAY. By T. V. Holmes. 'Essex Naturalist,' XII. 60–62. 1901.

INDEX.

References to reports and papers printed in extenso *are given in Italics.*
*An Asterisk * indicates that the title only of the communication is given.*
The mark † indicates the same, but a reference is given to the Journal or Newspaper where the paper is published in extenso.

OBJECTS and rules of the Association, xxix.

List of Presidents, Vice-Presidents, and Local Secretaries, 1831–1902, xl.

List of Trustees and General Officers, 1831–1902, liii.

List of former Presidents and Secretaries of Sections, liv.

List of evening Discourses from 1842, lxxiii.

Lectures to the Operative Classes, lxxvi.

Officers of Sections present at Belfast, lxxvii.

Committee of Recommendations at Belfast, lxxix.

Treasurer's account, lxxx.

Table showing the attendance and receipts at the annual meetings, lxxxii.

Officers and Council for 1902–1903, lxxiv.

Report of the Council to the General Committee at Belfast, lxxxv.

Resolutions passed by the General Committee at Belfast:
- (1) Committees receiving grants of money, lxxxviii.
- (2) Committees not receiving grants of money, xciii.
- (3) Papers ordered to be printed *in extenso*, xvii.
- (4) Resolutions referred to the Council for consideration, and action if desirable, xcvii.

Synopsis of grants of money appropriated to scientific purposes in 1902, xcviii.

Places of meeting in 1903 and 1904, xcix.

General statement of sums which have been paid on account of grants for scientific purposes, c.

General meetings, cxviii.

Address by the President, Professor James Dewar, F.R.S., 3.

ABERCROMBY (Hon. J.), the oldest bronze-age ceramic type in Britain; its close analogies on the Rhine; its probable origin in Central Europe, 755.

ABNEY (Sir W. de W.) *on wave-length tables of the spectra of the elements and compounds*, 137.

Absorption and radiation, some experiments on, by J. E. Petavel, 534.

Absorption spectra and chemical constitution of organic substances, the relation between the, report on, 99.

Absorption spectra of phloroglucinol and some of its derivatives, Profs. W. N. Hartley and J. J. Dobbie and A. Lauder on the, 99.

Acid esters of methyl succinic acids, by Prof. J. J. Sudborough and Dr. W. A. Bone, 586.

ACKROYD (W.), the telluric distribution of the elements in relation to their atomic weights, 581.

Acœlous turbellarian inhabiting the common heart urchin, R. T. Leiper on an, 652.

ADAMS (Prof. W. G.) *on practical electrical standards*, 53.

—— *on comparing and reducing magnetic observations*, 58.

—— *on magnetic observations at Falmouth*, 75.

Aërial gliders, the longitudinal stability of, by Prof. G. H. Bryan, 524.

Age of stone circles, report on explorations to ascertain the, 455.

—— *the excavations at Arbor Low, May–June* 1902, *by H. St. G. Gray*, 455.

AITKEN (T.) *on the resistance of road vehicles to traction*, 314.

Algæ of the Bay of Naples, Miss A. Vickers on the, 262.

Alkylation of sugars, T. Purdie and Dr. J. C. Irvine on the, 583.

ALLANSON-WINN (R. G.), the direction and velocity of material-bearing ocean currents, with description of an apparatus recently designed for estimating the same, 737.

ALLEN (B.), the effects on Ireland of the adoption of free trade by the United Kingdom, 703.

Alloys, the nature of, report on, 175.

All-stations express train, an, by J. Brown, 732.

Aluminium alloys, the electrical conductivity of certain, as affected by exposure to London atmosphere, by Prof. E. Wilson, 734.

Aluminium tubes, light, F. H. Nalder on, 551.

*Ammonia, the absorption of, from water by algæ, Prof. E. A. Letts and J. S. Totton on, 587.

Amphipods collected by Professor Herdman, A. O. Walker on the, 643.

Amphioxus, the structure and development of the excretory apparatus of the, E. S. Goodrich on, 260.

ANDERSON (Prof. R. J.) on a specimen of the pilot whale (*Globiocephalus melas*), 650.

—— the connection of the anterior inferior angle of the parietal bone in primates, 651.

—— some inquiry into the physics of the flow of fluids in plant stems, 817.

ANDERSON (Dr. Tempest) *on the collection of photographs of geological interest*, 229.

*ANDREWS (Dr. C. W.) on the tusks and skull of *Mastodon angustidens*, 599.

—— on a diagram of the skull of the *Mastodon angustidens*, 654.

Animal thermostat, Lord Kelvin on an, 543.

*ANNANDALE (Nelson), flower-like insects from the Malay Peninsula, 649.

—— human souls and ghosts among the Malays of Patani, 752.

—— and H. C. ROBINSON on the wild and civilised races of the Malay Peninsula, 766.

Antarctic expedition, the Scottish national, W. S. Bruce on, 686.

Antarctic exploration, the motives of, by Dr. H. R. Mill, 685.

*Anthropological museum, the classification and arrangement of the exhibits in an, W. H. Holmes on, 770.

Anthropological photographs, interim report on the collection of, 449.

Anthropology, Address by Dr. A. C. Haddon to the Section of, 738.

*—— suggestions for the classification of the subject-matter of, by E. N. Fallaize, 770.

*Anthropology, physical, exhibition of specimens illustrating, by Prof. J. Symington, 753.

*——, ——, demonstration on specimens illustrating points in, by Prof. J. Symington, 770.

Anthropometric investigations among the native troops of the Egyptian army, interim report on, 350.

Araucarieæ, the morphology of the, Miss S. O. Ford on, 810.

ARBER (E. A. N.), the fossil flora of the Cumberland coalfield, 611.

—— on the morphology of the flowers in certain species of *Lonicera*, 816.

*—— and A. C. SEWARD, fossil *Nipa* fruits from Belgium, 808.

Arbor Low, the excavations at, May–June 1902, H. St. G. Gray on, 455.

ARCHIBALD (D.) *on the investigation of the upper atmosphere by means of kites*, 77.

ARMSTRONG (Dr. E. F.), recent synthetical researches in the glucoside group, 578.

—— the synthetical action of enzymes, 579.

ARMSTRONG (Prof. H. E.) *on statistics concerning the training of chemists employed in English chemical industries*, 97.

—— *on isomeric naphthalene derivatives*, 176.

—— *on isomorphous sulphonic derivatives of benzene*, 180.

—— *on the teaching of science in elementary schools*, 481.

—— Address to the Section of Educational Science by, 820.

Aromatic diazo-compounds, our present knowledge of, by Dr. G. T. Morgan, 181.

Arrow- and spear-heads, the manufacture of, by W. J. Knowles, 758.

ASHLEY (P.), municipal policy and State control, 700.

*Asilidæ, the habits of the predaceous flies of the family of, Prof. E. B. Poulton on, 647.

Astronomy and Cosmical Physics, Address by Prof. A. Schuster to the Department of, 512.

Atlantis problem, Dr. R. F. Scharff on the, 653.

Atmosphere, the upper, investigation of, by means of kites, report on, 77.

*Atmospheric carbonic anhydride, determinations of, made on board the 'Discovery,' Prof. E. A. Letts on, 587.

Australian Alps, a census of the flora of the, James Stirling on, 799.

Australian fauna, T. Steel on examples of, 650.

*Australian native cat (*Dasyurus*), the segmentation and early developmental stages of the, by Prof. G. B. Howes, 649.

*Australian plants, exhibition of some characteristic, by T. Steel, 802.

AVEBURY (Lord) *on the teaching of science in elementary schools*, 481.

AVELING (T. C.) *on the resistance of road vehicles to traction*, 314.

*Axolotl, experiments on the, by E. J. Bles, 657.

AYRTON (Prof. W. E.) *on practical electrical standards*, 53

Bacteria, luminous, J. E. Barnard and Prof. A. Macfadyen on, 801.

Bagshot beds, the occurrence of, at Combe Pyne, near Lyme Regis, H. B. Woodward on, 601.

BAILEY (Lieut.-Col.) *on terrestrial surface-waves and wave-like surfaces*, 285.

BALFOUR (H.) *on the collection of anthropological photographs*, 449.

—— *on the age of stone circles*, 455.

*BALFOUR (Prof. I. Bayley), exhibition of forms of *Erica Tetralix* from Connemara, 799.

*BARCROFT (J.), the estimation of urea in physiological fluids, 784.

BARKER (B. T. P.), samsu, a fermented drink of Eastern Asia, and its characteristic fungus, 818.

BARNARD (J. E.) and Prof. A. MACFADYEN on luminous bacteria, 801.

BARNES (Dr. H. T.), further experiments by the thermal method on the variation of the critical velocity of water with temperature, 512.

—— and H. L. COOKE on the variation of the specific heat of mercury with temperature, 530.

BARR (Mark) *on the B.A. screw gauge*, 350.

BARRINGTON (R. M.) *on working out the details of the observations on the migration of birds*, 273.

BARROW (G.) on the prolongation of the Highland border rock into co. Tyrone, 610.

BATHER (Dr. F. A.) *on life-zones in the British Carboniferous rocks*, 210.

—— *on the compilation of an index generum et specierum animalium*, 283.

BEARE (Prof. T. Hudson) *on the resistance of road vehicles to traction*, 314.

BEAUMONT (W. W.) *on the resistance of road vehicles to traction*, 314.

BEILBY (G. T.) *on statistics concerning the training of chemists employed in English chemical industries*, 97.

Belfast, the geology of the country in the neighbourhood of, Prof. G. A. J Cole on, 596.

Belfast, some urgent needs of, by Miss L. A. Walkington, 709.

—— district, the post-glacial deposits of the, R. Lloyd Praeger on, 611.

BELL (C. N.) *on an ethnological survey of Canada*, 353.

Ben Nevis, meteorological observations on, report on, 93.

BENSON (Miss M.), the seed-like fructification of *Miadesmia membranacea* (Bertrand), a lycopodiaceous plant from the coal measures, 808.

—— a possible calymmatotheca type of fructification showing structure, 808.

Benzene, isomorphous sulphonic derivatives of, third report on, 180.

BEVAN (Rev. J. O.) *on the work of the Corresponding Societies Committee*, 851.

BINGLEY (Godfrey) *on the collection of photographs of geological interest*, 229.

BINNIE (Sir Alexander) *on the resistance of road vehicles to traction*, 314.

Bird fauna of Ireland, the, as affected by its geography, by R. J. Ussher, 658.

Birds, the observations on the migration of, 1880–1887, *fifth interim report on working out the details of*, 273.

BLACKBURN (Miss H.), nature's economics, 708.

BLACKMAN (Dr. F. F.) *on the cyanophyceæ*, 473.

BLAKE (Rev. J. F.) *on the registration of type specimens of British fossils*, 210.

—— on the original form of sedimentary deposits, 603.

BLANFORD (Dr. W. T.) *on the zoology of the Sandwich Islands*, 284.

*BLES (E. J.), the development of *Xenopus* (*Dactylethra*), 657.

*—— experiments on the Axolotl: adaptations to life in an alkaline medium, 657.

BLOUNT (Bertram), the undesirability of establishing standard analytical methods, 577.

BONE (Dr. W. A.) and Prof. J. J. SUDBOROUGH, acid esters of methyl succinic acids, 586.

BONNEY (Prof. T. G.) *on seismologica investigation*, 59.

—— *on the collection of photographs of geological interest*, 229.

—— *on the erratic blocks of the British Isles*, 252.

—— *on the work of the Corresponding Societies Committee*, 851.

BOOTH (Dr. C.) *on the economic effect of legislation regulating women's labour*, 286.

BOOTH (W. H.), the smokeless combustion of bituminous fuel, 736.

*— — the Solignac boiler, 736.

*BOSANQUET (R. C.), excavations at Palæokastro in Eastern Crete, 770.

BOSE (Prof. J. C.), electric response of ordinary plants under mechanical stimulus, 802.

Botanical photographs, the registration of negatives of, report on, 471.

Botany, Address by Prof. J. R. Green to the Section of, 785.

BOTTOMLEY (Dr. J. T.) *on practical electrical standards*, 53.

BOURINOT (Sir J.) *on an ethnological survey of Canada*, 353.

BOURNE (G. C.) *on the micro-chemistry of cells*, 470.

BOWER (Prof. F. O.) *on investigations in the laboratory of the Marine Biological Association of the West of Scotland at Millport*, 272.

BOWLEY (A. L.) *on the economic effect of legislation regulating women's labour*, 286; *report on the West Riding of Yorkshire*, 291.

BOYLE (D.) *on an ethnological survey of Canada*, 353.

BOYS (C. Vernon) *on seismological investigation*, 59.

—— *on the investigation of the upper atmosphere by means of kites*, 77.

—— *on the B.A. screw gauge*, 350.

BRABROOK (E. W.) *on the economic effect of legislation regulating women's labour*, 286.

—— *on a pigmentation survey of the school children of Scotland*, 352.

—— *on an ethnological survey of Canada*, 353.

—— *on the Roman fort at Gellygaer*, 450.

—— *on the Silchester excavation*, 453.

—— *on the conditions of health essential to the carrying on of the work of instruction in schools*, 483.

BRAMWELL (Sir F. J.) *on the B.A. screw gauge*, 350.

*—— a universal language, 847.

BRAY (G.) *on the movements of underground waters of North-west Yorkshire*, 224.

British carboniferous rocks, life-zones in the, report on, 210.

British fisheries' investigations and the international scheme, Prof. W. C. McIntosh on, 638.

British fossils, the registration of type specimens of, report on, 210.

British Zollverein, a, or preferential tariffs within the British Empire, by Judge Shaw, 702.

Brockrams of the Vale of Eden, the, and the evidence they afford of an inter-Permian movement of the Pennine faults, P. F. Kendall on, 604.

BRODIE (Dr. T. G.) *on the work of the mammalian heart*, 470.

BROMWICH (Prof.) and R. W. H. T. HUDSON, the discriminant of a family of curves or surfaces, 526.

Bronze-age ceramic type in Britain, the oldest; its close analogies on the Rhine; its probable origin in Central Europe, by Hon. J. Abercromby, 755.

BROWN (Prof. A. Crum) *on meteorological observations on Ben Nevis*, 93.

BROWN (Dr. H. T.) *on the work of the Corresponding Societies Committee*, 851.

BROWN (J.) *on the resistance of road vehicles to traction*, 314.

—— a new elastic vehicle wheel, 731.

—— an all-stations express train, 732.

BROWN (R.), the increase of consumption in Ireland, 709.

BRUCE (W. S.), the Scottish national antarctic expedition, 686.

BRUCE-KINGSMILL (Capt. J.), Mr. Petavel's recording gauge applied to ordnance and small arms, 538.

BRYAN (Prof. G. H.), the longitudinal stability of aërial gliders, 524.

*—— the positions of hydrogen and helium in relation to the earth's atmosphere, 556.

BUCHAN (Dr. A.) *on the investigation of the upper atmosphere by means of kites*, 77.

—— *on meteorological observations on Ben Nevis*, 93.

BUCKLEY (R. B.), colonisation and irrigation in Uganda and the British East Africa Protectorate, 679.

BULLEY (A. Amy), a study in the psychology of primitive man, 764.

BURKE (J. B.) on luminosity and the kinetic theory, 549.

BURRARD (Major S. G.) on the figure of the earth, 541.

BURTON (F. M.) *on the erratic blocks of the British Isles*, 252.

*CALDWELL (W.) and Prof. E. A. LETTS on experiments to ascertain the amount of carbonic anhydride absorbed from the sea-water by air, 576.

CALLENDAR (Prof. H. L.) *on practical electrical standards*, 53.

Calymmatotheca type of fructification, a possible, showing structure, by Miss M. Benson, 808.

Cambro-Ordovician succession near Tremadoc, the bearing of some new fossils from Penmorfa on the, by W. G. Fearnsides, 614.

*Camel, the nervous system of the, by Dr. W. Page May, 782.

CAMPBELL (Rev. J.) *on an ethnological survey of Canada*, 353.

Canada, an ethnological survey of, report on, 353.

Cannan (Dr. E.), Address to the Section of Economic Science and Statistics by, 688.

Carbon dioxide assimilation, the effect of temperature on, by Miss G. L. C. Matthaei, 805.

*Carbonic anhydride absorbed from the sea-water by air, experiments to ascertain the amount of, Prof. E. A. Letts and W. Caldwell on, 576.

Carboniferous fish fauna from Victoria, Australia, Dr. A. S. Woodward on a, 615.

Carpenter (G. H.) on the insect fauna of some Irish caves, 657.

Carter (Rev. W. Lower) *on the movements of underground waters of North-west Yorkshire*, 224.

*Celestial photographs from the Yerkes Observatory, exhibition of, by A. R. Hinks, 551.

Cells, the micro-chemistry of, report on, 470.

Cestodes and trematodes parasitic on fishes, N. Maclaren on, 260.

Ceylon, foliar periodicity in, by Herbert Wright, 807

—— the scenery of, A. K. Coomáraswámy on, 613.

Changes, the principal, in South-east England during Pliocene and more recent times, a summary of, by H. W. Monckton, 616.

Chapman (Prof. S. J.) *on the economic effect of legislation regulating women's labour*, 286; *in the cotton industry of Lancashire*, 287.

—— the regulation of wages in developed industries, 708.

*Charnwood Forest, a buried triassic landscape, by Prof. W. W. Watts, 687.

Chemical constitution and absorption spectra of organic substances, the relation between the, report on, 99.

*Chemical reactions, the question as to the accurate conservation of weight in, Lord Rayleigh on, 511.

Chemistry, Address by Prof. E. Divers to the Section of, 557.

Chemists employed in English chemical industries, statistics concerning the training of, report on, 97.

Chick (Miss E.) and Prof. F. W. **Oliver** on the morphology of the seed and seedling of *Torreya*, 814.

Chree (Dr. C.) *on comparing and reducing magnetic observations*, 58.

***Christen** (Madame), investigations into the glacial drifts of the north-east of Ireland, 604.

Christie (W. H. M.) *on comparing and reducing magnetic observations*, 58.

Chrystal (Prof. G.) *on comparing and reducing magnetic observations*, 58.

Chrystal (Prof. G.) *on the teaching of elementary mathematics*, 473.

Cinnamic acid dibromide and its esters, action of alkalis on, by Prof. J. J. Sudborough and K. J. Thompson, 587.

Clark (A. B.), the influence of economic history on economic theory, 695.

Clark (R.) on the fossils of the Silurian area of N.E. Ireland, 599.

Clarke (W. Eagle) *on the migration of birds: the fieldfare* (Turdus pilaris), 274; *the lapwing* (Vanellus vulgaris), 277.

Cleland (Prof.) on a hitherto unrecorded element in the occipital bone of seals, 646.

Clements (O. P.) *on the B.A. screw gauge*, 350.

Clinch (G.) on some ancient subterranean chambers recently discovered at Waddon, near Croydon, 754.

Clowes (Prof. F.), the action of distilled water upon lead, 576.

Coates (H.) *on the collection of photographs of geological interest*, 229.

Cod, the structure of scales in the, Dr. H. W. M. Tims on, 660.

Coffey (G.) *on the Kesh caves, co. Sligo*, 247.

—— on the occurrence in Ireland of objects of Hallstatt types, 760

Cole (Prof. G. A. J.) *on the Kesh caves, co. Sligo*, 247.

—— the geology of the country in the neighbourhood of Belfast, 596.

—— on the structure of Ireland, 609.

Collet (Miss C. E.) *on the economic effect of legislation regulating women's labour*, 286.

Colloids of zirconium, compared with those of other metals of the fourth group, by Dr. J. H. Gladstone and W. Hibbert, 585.

Colour vision, the physical aspects of a theory of, by Dr. F. W. Edridge-Green, 549.

Conditions of health essential to the carrying on of the work of instruction in schools, report on, 483.

*Conservation of weight in chemical reactions, the accurate, Lord Rayleigh on the question as to, 511.

Consumption in Ireland, the increase of, by R. Brown, 709.

*Continuous motion produced by vibrations, Prof. W. B. Morton and A. M. Kinsky on, 511.

Cooke (H. L.) and Dr. H. T. **Barnes** on the variation of the specific heat of mercury with temperature, 530.

Coomáraswámy (A. K.) on the scenery of Ceylon, 613.

Copeland (Prof.) *on meteorological observations on Ben Nevis*, 93.

Copepod sub-family Aetidiinæ, *Dr. R. N. Wolfenden on the*, 263.

*Copper, on the corrosion of, by sea-water, and on the detection of traces of impurity in the commercial metal, by Prof. E. A. Letts, 576.

Coral reefs of the Indian region, third report on the, 284.

Coral rock, the breaking-up of, by organisms in the tropics, by J. S. Gardiner, 654.

Cork river-valleys, J. Porter on some features of the, 684.

*Cornelius Magrath, the Irish giant, Prof. D. J. Cunningham on, 753.

CORNISH (Dr. Vaughan) *on terrestrial surface-waves and wave-like surfaces*, 285.

—— on regular undulations produced in a road by the use of sledges, 730.

Corresponding Societies Committee:
  Report, 851.
  Conference at Belfast, 856.
  List of Corresponding Societies, 874.
  Papers published by Corresponding Societies, 877.

CORTIE (Rev. A. L.), minimum sunspots and terrestrial magnetism, 522.

Cosmical Physics and Astronomy, Address by Prof. A. Schuster to the Department of, 512.

*Craniometry, radial, a method of, Dr. C. S. Myers on, 760.

CREAK (Capt. E. W.) *on comparing and reducing magnetic observations*, 58.

—— *on magnetic observations at Falmouth*, 75.

CRICK (G. C.) *on life-zones in the British carboniferous rocks*, 210.

Critical velocity of water, the variation of, with temperature, further experiments by the thermal method on, by Dr. H. T. Barnes, 512.

CROMPTON (Col. R. E.) *on the resistance of road vehicles to traction*, 314.

—— *on the B.A. screw gauge*, 350.

CROOK (C. V.) *on the collection of photographs of geological interest*, 229.

CROSSLEY (Dr. A. W.) *on hydro-aromatic compounds with single nucleus*, 120.

Cumberland coalfield, the fossil flora of the, by E. A. N. Arber, 611.

CUNNINGHAM (Lt.-Col. Allan) on pluperfect numbers, 528.

CUNNINGHAM (Prof. D. J.) *on the Kesh caves, co. Sligo*, 247.

—— *on anthropometric investigations among the native troops of the Egyptian army*, 350.

—— *on a pigmentation survey of the school children of Scotland*, 352.

*——, Cornelius Magrath, the Irish giant, 753.

CUNNINGHAM (Rev. W.), the localisation of industry, 695.

CUNNINGTON (W. and Dr. W. A.) on a recent find of palæolithic flint implements at Knowle, Wiltshire, 759.

Curves of molecular vibrations of quinone, p-nitroso-phenol and similarly derived substances, report on the, 107.

*Cuttlefishes collected by Prof. Herdman, W. E. Hoyle on the, 644.

Cyanophyceæ, the investigation of the, report on, 473.

*—— the nucleus of the, by H. Wager, 816.

*Darnel seed-fungus, the, by E. M. Freeman, 819.

DARWIN (Francis) *on the coral reefs of the Indian region*, 284.

—— *on botanical photographs*, 471.

—— *on the respiration of plants*, 472.

DARWIN (Prof. G. H.) *on seismological investigation*, 59.

DARWIN (H.) *on seismological investigation*, 59.

—— *on relative movements of the strata at the Ridgeway fault*, 75.

DARWIN (Maj. L.) *on seismological investigation*, 59.

DAVIES (J. H.), *Weisia rostellata*, Lindb., in Ireland, 819.

DAWKINS (Prof. Boyd) *on the age of stone circles*, 455.

Decimalisation of English money, the late J. Hamblin Smith's rule for the, by J. D. H. Dickson, 529.

Depopulation of Ireland, the: its causes and economic results, by J. H. Edgar, 705.

*Deposit of dew on the lenses of a projecting lantern, the prevention of a, Prof. A. Schuster on, 511.

DE RANCE (C. E.) *on the erratic blocks of the British Isles*, 252.

*Determinants, a theorem in, by A. A. Robb, 530.

DEWAR (Prof. J.), *Presidential Address*, 3.

—— *on wave-length tables of the spectra of the elements and compounds*, 137.

Diamonds, fluorescent and phosphorescent, Dr. J. H. Gladstone on, 586.

*DICK (F. J.), water power in Ireland, 733.

DICKSON (J. D. H.), the late J. Hamblin Smith's rule for the decimalisation of English money, 529.

Differential equations, the partial, of mathematical physics, E. T. Whittaker on, 523.

DINES (W. H.) *on the investigation of the upper atmosphere by means of kites*, 77.

Diospyros, sex in the Ceylon species of, by H. Wright, 819.
Discharge curve of a condenser, a graphical method of determining the, through a variable self-induction, by Dr. E. W. Marchant, 548.
Discriminant of a family of curves or surfaces, the, by Prof. Bromwich and R. W. H. T. Hudson, 526.
Discussions:
  *On the nebula surrounding Nova Persei, 521.
  *On the interpretation of variation phenomena by the theory of natural selection, 650.
  *On mimicry and natural selection, 661.
  *On the training of engineers, 847.
  *On the training of teachers, 847.
  *On the teaching of English, 847.
  *On the teaching of mathematics, 848.
*Diuretic action of pituitary extracts, Prof. E. A. Schäfer on the, 780.
DIVERS (Prof. E.), Address to the Section of Chemistry by, 557.
DIXON (Prof. A. C.) on map-colouring, 525.
—— on the Newtonian potential, 526.
*DIXON (Prof. A. F.) on a skull modified by acromegaly, 753.
DIXON (Dr. H. H.), resistance of seeds to high temperatures, 805.
DOBBIE (Prof. J. J.) *on the relation between the absorption spectra and chemical constitution of organic substances*, 99; *on the absorption spectra of phloroglucinol and some of its derivatives*, 99.
*Dogs, recent intercrossing experiments with, by Prof. J. C. Ewart, 649.
Dorsiventrality of the podostemaceæ, the, with reference to current views on evolution, J. C. Willis on, 806.
*Drift map of the Dublin area, the, by J. J. H. Teall, 602.
DUNSTAN (Prof. W. R.) *on the teaching of science in elementary schools*, 481.
DWERRYHOUSE (A. R.) *on the movements of underground waters of North-west Yorkshire*, 224.
—— *on the erratic blocks of the British Isles*, 252.
*Dynamo, H. A. Mavor on the making of a, 736.
*Dynamo construction, the specific utilisation of materials in, Prof. S. P. Thompson on, 735.

Earth, the figure of the, Major S. G. Burrard on, 541.
Earthquakes, world-shaking, in relation to volcanic eruptions in the West Indies, by J. Milne, 682.
Economic history, the influence of, on economic theory, by A. B. Clark, 695.
Economic Science and Statistics, Address by Dr. E. Cannan to the Section of, 688.
Economic theory, the influence of economic history on, by A. B. Clark, 695.
Economics and the applied sciences, the position of, in a proposed university training of persons intended for a commercial life, by Dr. W. R. Scott, 696.
EDGAR (J. H.), the depopulation of Ireland: its causes and economic results, 705.
EDGEWORTH (Prof. F. Y.) *on the economic effect of legislation regulating women's labour*, 286.
*Edinger's apparatus for higher magnifications and stronger light, demonstration of, by Prof. J. Symington and Dr. Cecil Shaw, 784.
EDRIDGE-GREEN (Dr. F. W.), the physical aspects of a theory of colour vision, 549.
*—— the functions of the rods and cones of the retina, 780.
*Education, intermediate, in Ireland, R. M. Jones on, 846.
*——, ——, Rev. Father Murphy on, 846.
*——, Irish, recent reforms in, Dr. W. J. M. Starkie on, 844.
Educational Science, Address by Prof. H. E. Armstrong to the Section of, 820.
EDWARDS (Major W. E.), Capt. C. H. LIVEING, and Prof. W. R. HODGKINSON, the reduction of some metallic chlorides by calcium carbide, 585.
EGGAR (W. D.) *on the teaching of elementary mathematics*, 473; *suggested schedule of experimental geometry*, 478.
Egyptian army, anthropometric investigations among the native troops of the interim report on, 350.
Electric response of ordinary plants under mechanical stimulus, by Prof. J. C. Bose, 802.
Electrical conductivity of certain aluminium alloys as affected by exposure to London atmosphere, Prof. E. Wilson on the, 734.
Electrical instruments, M. B. Field on some, 734.
Electrical measurements, experiments for improving the construction of practical standards for, report on, 53.
Elema, the religious ideas, totems, spirits, and gods of, by Rev. J. H. Holmes, 752.
Elementary mathematics, the teaching of, report on, 473.
——, ——, A. W. Siddons on, 848.
*Ellipse, a practical rule for finding the perimeter of an, by T. Muir, 529.

ELLIS (W.) *on comparing and reducing magnetic observations*, 58.

ELPHINSTONE (G. K. B.) *on the B.A. screw gauge*, 350.

ELWORTHY (F. T.) on perforated stone amulets, 767.

*Embryonic cell, the significance of the, Prof. C. S. Minot on, 658.

Engineering, Address by Prof. J. Perry to the Section of, 711.

*Engineering work, the importance of minor details in, by M. H. Smith, 735.

*Engineers, the training of, discussion on, 847.

*English, the teaching of, discussion on, 847.

English grammar, the neglect of, by Prof. Minchin, 847.

Entropy, the application of the method of, to radiant energy, Dr. J. Larmor on, 546.

Enzymes, the synthetical action of, by Dr. E. F. Armstrong, 579.

Equations of state, H. H. F. Hyndman on, 535.

*_Erica Tetralix_, exhibition of forms of, from Connemara, by Prof. I. Bayley Balfour, 799.

Erratic blocks of the British Isles, report on the, 252.

*Eskimo of Southampton Island, some measurements of, J. F. Tocher on, 762.

*Ethnography of the Nagas, Dr. W. H. Furness on the, 770.

Ethnological studies of the mainland Halkōmē'lem, a division of the Salish of British Columbia, by C. Hill-Tout, 355.

Ethnological survey of Canada, report on an, 353.

*Eupomatus and Polygordius, early development of the head-kidney in, C. Shearer on, 661.

EVANS (A. H.) *on working out the details of the observations on the migration of birds*, 273.

EVANS (A. J.) *on the Roman fort at Gellygaer*, 450.

—— *on the Silchester excavation*, 453.

—— *on the age of stone circles*, 455.

—— *on explorations at Knossos in Crete*, 466.

EVANS (Sir J.) *on anthropometric investigations among the native troops of the Egyptian army*, 350.

—— *on the age of stone circles*, 455.

—— *on explorations at Knossos in Crete*, 466.

—— *on the work of the Corresponding Societies Committee*, 851.

EVE (H. W.) *on the teaching of elementary mathematics*, 473.

*Evenlode, the windings of the, Dr. A. J. Herbertson on, 683.

EVERETT (Prof. J. D.) *on practical electrical standards*, 53.

*—— on the graphical representation of Ramsay and Young's law for the comparison of vapours at equal pressures, 537.

EWART (Prof. J. Cossar) *on investigations in the laboratory of the Marine Biological Association of the West of Scotland at Millport*, 272

* —— recent intercrossing experiments with dogs, 649.

EWING (Prof. J. A.) *on seismological investigation*, 59.

Expedition for ascertaining the best location of observatories, by P. Lowell, 554.

Factory and Workshops Acts, the administration of the, by local sanitary authorities, by Miss A. Harrison. 707.

FAIRLEY (T.) *on the movements of underground waters of North-west Yorkshire*, 224.

*FALLAIZE (E. N.), suggestions for the classification of the subject-matter of anthropology, 770.

FARMER (Prof. J. B.) *on the respiration of plants*, 472.

—— *on the cyanophyceæ*, 473.

*Fatty seeds, the germination of, Prof. J. R. Green and H. Jackson on, 804.

FAWSITT (Dr. C. E.), the decomposition of urea, 578.

FEARNSIDES (W. G.) on some new fossils from Penmorfa, and their bearing on the Cambro-Ordovician succession near Tremadoc, 614.

FENNELL (W. J.) on some Ulster souterrains, 753.

FIELD (M. B.), some electrical instruments, 734.

Fieldfare (Turdus pelaris), *the migrations of the, W. Eagle Clarke on*, 274.

Fish fauna of the Pendleside limestones, a list of the, by E. D. Wellburn, 222.

Fishes, the scales of, as an index of age, by J. S. Thomson, 642.

FITZPATRICK (Rev. T. C.) *on practical electrical standards*, 53.

*Flashing lighthouse light, a new, without intervals of darkness, by J. R. Wigham, 735.

FLEMING (Prof. J. A.) *on practical electrical standards*, 53.

Flora of the north-east of Ireland, the composition of the, by R. Lloyd Praeger, 815.

Flora of the Australian Alps, a census of the, James Stirling on, 799.

Flow of fluids in plant stems, some inquiry into the physics of the, by Prof. R. J. Anderson, 817.

*Flower-like insects from the Malay Peninsula, by Nelson Annandale, 649.

FLOYER (E. A.) *on terrestrial surface-waves and wave-like surfaces*, 285.

FLUX (Prof. A. W.) *on the economic effect of legislation regulating women's labour*, 286.

Foliar periodicity in Ceylon, by Herbert Wright, 807.

FOORD (Dr. A. H.) *on life-zones in the British carboniferous rocks*, 210.

*FORBES (Prof. G.), experiences with the infantry range-finder in the South African war, 736.

FORBES (Dr. H. O.) *on working out the details of the observations on the migration of birds*, 273.

FORD (Miss S. O.), on the morphology of the araucarieæ, 810.

FORSYTH (Prof.) *on the teaching of elementary mathematics*, 473.

Fossil fishes of the Lower Devonian roofing-slate of Gemünden, Germany, Dr. R. H. Traquair on the, 610.

Fossil flora of the Cumberland coalfield, E. A. N. Arber on the, 611.

*Fossil *Nipa* fruits from Belgium, by A. C. Seward and E. N. Arber, 808.

'Fossil' water, the so-called, of sedimentary strata, as illustrated by the sandstones of the Moray Firth basin, by Dr. W. Mackie, 608.

Fossils, British, the registration of type specimens of, report on, 210.

—— from the cretaceous strata in the Salt Range of India, Prof. H. G. Seeley on, 604.

—— of the Silurian area of N. E. Ireland, R. Clark on the, 599.

—— some new, from Penmorfa, and their bearing on the Cambro-Ordovician succession near Tremadoc, W. G. Fearnsides on, 614.

FOSTER (A. Le Neve) *on the B.A. screw gauge*, 350.

FOSTER (Prof. G. C.) *on practical electrical standards*, 53.

FOX (H.) *on life-zones in the British carboniferous rocks*, 210.

FOX (W. L.) *on magnetic observations at Falmouth*, 75.

Free trade, the effects on Ireland of the adoption of, by the United Kingdom, by B. Allen, 703.

*FREEMAN (E. M.), the Darnel seed-fungus, 819.

Fresh-water lakes of the British Isles, the survey of the, by T. N. Johnston, 680.

*FURNESS (Dr. W. H.) on the ethnography of the Nagas, 770.

GALTON (F.) *on the work of the Corresponding Societies Committee*, 851.

GANONG (Dr. W. F.) *on an ethnological survey of Canada*, 353.

GARDINER (J. Stanley), the breaking-up of coral rock by organisms in the tropics, 654.

GARDINER (W.) *on the cyanophyceæ*, 473.

GARSON (Dr. J. G.) *on the collection of anthropological photographs*, 449.

—— *on the age of stone circles*, 455.

—— *on the work of the Corresponding Societies Committee*, 851.

GARSTANG (W.) *on investigations made at the Marine Biological Laboratory, Plymouth*, 271.

*—— the international investigation of the North Sea, 641.

GARWOOD (Prof. E. J.) *on life-zones in the British carboniferous rocks*, 210.

—— *on the collection of photographs of geological interest*, 229.

*Gas-engine explosions, a note on, by Prof. J. Perry, 737.

—— a preliminary note on, by H. E. Wimperis, 736.

Gas-engines, large, recent progress in, by H. A. Humphrey, 729.

GEIKIE (Prof. J.) *on the collection of photographs of geological interest*, 229.

Gellygaer, the Roman fort at, report on, 450.

GEMMILL (Dr. J. F.) *on investigations in the laboratory of the Marine Biological Association of the West of Scotland at Millport*, 272.

Geographical plant-groups in the Irish flora, by R. Lloyd Praeger, 683.

Geography, Address by Col. Sir T. H. Holdich to the Section of, 662.

Geography of Southern Persia, the, as affecting its history, Major P. M. Sykes on, 677.

*Geological map of Victoria, the new, J. Stirling on, 603.

Geological photographs, thirteenth report on the collection of, 229.

Geology, Address by Lieut.-Gen. C. A. McMahon to the Section of, 589.

—— of the country in the neighbourhood of Belfast, Prof. G. A. J. Cole on the, 596.

Geometry, experimental, two suggested schedules of, by Mr. Eggar, 478; *and Prof. Perry*, 479.

GIBBS (Prof. Wolcott) *on wave-length tables of the spectra of the elements and compounds*, 137.

GIBSON (Prof.) *on the teaching of elementary mathematics*, 473.

GIFFORD (J. W.), a lens for ultra-violet therapy, 537.

*GILL (T. P.), the relation of technical instruction to industrial development in Ireland, 847.

Ginsburg (Dr. B. W.), shipping combinations, 698.

*Glacial drifts of the North-east of Ireland, investigations into the, Madame Christen on, 604.

Gladstone (G.) *on the teaching of science in elementary schools*, 481.

Gladstone (Dr. J. H.) *on the teaching of elementary mathematics*, 473

—— *on the teaching of science in elementary schools*, 481.

—— on fluorescent and phosphorescent diamonds, 586.

—— and W. Hibbert, colloids of zirconium, compared with those of other metals of the fourth group, 585.

Glazebrook (Dr. R. T.) *on practical electrical standards*, 53.

—— *on seismological investigation*, 59.

—— *on magnetic observations at Falmouth*, 75.

—— *on the B.A. screw gauge*, 350.

Glencoe, the volcanic rocks of, and their relation to the granite of Ben Cruachan, H. Kynaston on, 602.

Glucoside group, recent synthetical researches in the, by Dr. E. F. Armstrong, 578.

*Glycogen, the hydrolysis of, by Dr. W. A. Osborne and S. Zobel, 780.

Godman (Dr. F. Du Cane) *on the zoology of the Sandwich Islands*, 284.

Gonner (Prof. E. C. K.), the population of England and Wales during the eighteenth century, 706.

Goodchild (J. G.) *on the collection of photographs of geological interest*, 229.

Goodrich (E. S.) *on the structure and development of the excretory apparatus of amphioxus*, 260.

Gooseberry, a disease of the, with notes on *Botrytis* and *Sclerotium*, by Miss A. L. Smith, 816.

Gorham (J. Marshall) *on the B.A. screw gauge*, 350.

*Gotch (Prof. F.), the indefatigability of medullated nerve, 784.

Graham (Dr. W.) on the mental and moral characteristics of the people of Ulster, 762.

Graham (Prof. W.), trusts: from the point of view of economical theory, 697.

Graphical method of determining the discharge curve of a condenser through a variable self-induction, a, by Dr. E. W. Marchant, 548.

Gray (H. St. G.) *on the excavations at Arbor Low, May-June* 1902, 455.

Gray (J.) *on a pigmentation survey of the school children of Scotland*, 352.

—— measurements of the Indian Coronation contingent, 760.

Gray (W.) *on the collection of photographs of geological interest*, 229.

Green (Prof. J. R.), Address to the Section of Botany by, 785.

*—— and H. Jackson on the germination of fatty seeds, 804.

Green (Rev. W. S.), the islet of Rockall, 686.

Greenhill (Prof.) *on the teaching of elementary mathematics*, 473.

*Greenland, with Lieut. Peary in, by Prof. W. Libbey, 687.

Gregory (Prof. R. A.) *on the teaching of elementary mathematics*, 473.

Griffiths (E. H.) *on practical electrical standards*, 53.

—— *on the nature of alloys*, 175.

Haddon (Dr. A. C.) *on a pigmentation survey of the school children of Scotland*, 352.

—— *on an ethnological survey of Canada*, 353.

—— Address to the Section of Anthropology by, 738.

Hadley (Miss) *on the economic effect of legislation regulating women's labour in Canning Town and the Isle of Dogs*, 805.

Halkōmē'lɛm, the mainland, a division of the Salish of British Columbia, ethnological studies of, by C. Hill-Tout, 355.

Halliburton (W. D.) *on the micro-chemistry of cells*, 470.

—— Address to the Section of Physiology by, 771.

—— and Dr. F. W. Mott, regeneration of nerves, 782.

Hallstatt types, the occurrence in Ireland of objects of, G. Coffey on, 760.

Halstead (R.) *on the economic effect of legislation regulating women's labour in Leicester and Northampton*, 286.

Hardanger Fjord, Norway, the valleys at the head of the, H. W. Monckton on, 612.

Hardcastle (Miss Frances) *on the theory of point-groups*, 81.

Harmer (F. W.) *on the erratic blocks of the British Isles*, 252.

Harmer (Dr. S. F.) *on the coral reefs of the Indian region*, 284.

Harrison (Miss A.), the administration of the Factory and Workshops Acts by local sanitary authorities, 707.

Harrison (Rev. S. N.) *on the erratic blocks of the British Isles*, 252.

Hartland (E. S.) *on an ethnological survey of Canada*, 353.

—— *on the collection of anthropological photographs*, 449.

—— the Lia Fáil of Tara, and election of kings by augury, 766.

—— on two Japanese 'bokū-to,' 767.

HARTLEY (Prof. W. N.) *on the relation between the absorption spectra and chemical constitution of organic substances*, 99; *on the absorption spectra of phloroglucinol and some of its derivatives*, 99.

—— *on wave-length tables of the spectra of the elements and compounds*, 137.

HARVIE-BROWN (J. A.) *on working out the details of the observations on the migration of birds*, 273.

HAWES (C. H.), the island of Sakhalin and its inhabitants, 684.

*HAWTHORN (W.) and Prof. W. B. MORTON, motion of a detached thread of liquid in a capillary tube, 511.

HAWTHORNE (J.) on a fourth methylmorphimethine, 582.

*Head-kidney in Polygordius and Eupomatus, C. Shearer on early development of the, 661.

Heat, the unit of, on the definition of, 55.

HELE-SHAW (Prof. H. S.) *on the resistance of road vehicles to traction*, 314.

*Helium and hydrogen, the positions of, in relation to the earth's atmosphere, by Prof. G. H. Bryan, 556.

HELLER (W. M.), the introduction of practical instruction into Irish national schools, 845.

Helmand Delta, the, and the great desert of Persia known as the Lut, Major P. M. Sykes on, 677.

HENDERSON (Prof. G. G.) *on statistics concerning the training of chemists employed in English chemical industries*, 97.

HENRICI (Prof.) *on the teaching of elementary mathematics*, 473.

HENRY (Augustine) on the Lolos and other tribes of Western China, 765.

*HERBERTSON (Dr. A. J.) on the windings of the Evenlode, 683.

HERDMAN (G. W.), a direct reducing levelling staff, 733.

HERDMAN (Prof. W. A.) *on the occupation of a table at the Zoological Station at Naples*, 259.

—— *on investigations in the laboratory of the Marine Biological Association of the West of Scotland at Millport*, 272.

—— *on the coral reefs of the Indian region*, 284.

*—— account of his recent expedition to the Indian Ocean, including work on the pearl oyster banks of the Gulf of Manaar, 643.

Hertzian oscillations, a new receiver for, by Prof. G. M. Minchin, 547.

HEWITT (C. J.) *on the B.A. screw gauge*, 350.

HEYCOCK (C. T.) *on the nature of alloys*, 175.

HIBBERT (H.) and Prof. J. J. SUDBOROUGH, compounds of trinitrobenzene with alkylated arylamines, 587.

HIBBERT (Walter) and Dr. J. H. GLADSTONE, colloids of zirconium, compared with those of other metals of the fourth group, 585.

HICKSON (Prof. S. J.) *on the occupation of a table at the Zoological Station at Naples*, 259.

—— *on the coral reefs of the Indian region*, 284.

—— *on the zoology of the Sandwich Islands*, 284.

Highland border rock, the prolongation of the, into co. Tyrone, G. Barrow on, 610.

HILL-TOUT (C.) *on an ethnological survey of Canada*, 353; *ethnological studies of the mainland Halkōmē'lem, a division of the Salish of British Columbia*, 355.

HIND (Dr. Wheelton) *on life-zones in the British carboniferous rocks*, 210.

HINDE (Dr. G. J.) *on life-zones in the British carboniferous rocks*, 210.

*HINKS (A. R.), exhibition of celestial photographs from the Yerkes Observatory, 551.

—— the uncertainty of our present knowledge of the distance of the sun, 555.

HODGKINSON (Prof. W. R.), Major W. E. EDWARDS, and Capt. C. H. LIVEING, the reduction of some metallic chlorides by calcium carbide, 585.

HOGARTH (D. G.) *on explorations at Knossos in Crete*, 466.

*HOLDEN (F.), a new magnetic testing instrument, 734.

HOLDICH (Col. Sir T. H.), Address to the Section of Geography by, 662.

HOLMES (Rev. J. H.), the initiation ceremonies of the natives of the Papuan Gulf, 752.

—— the religious ideas, totems, spirits, and gods of Elema, 752.

HOLMES (T. V.) *on the work of the Corresponding Societies Committee*, 851.

*HOLMES (W. H.) on the classification and arrangement of the exhibits in an anthropological museum, 770.

Home work, history of the regulation of, 1864–1901, by Miss B. L. Hutchins, 706.

HOPKINSON (J.) *on the work of the Corresponding Societies Committee*, 851.

HORNE (Dr. J.) *on the erratic blocks of the British Isles*, 252.

HOWES (Prof. G. B.) *on the occupation of a table at the Zoological Station at Naples*, 259.

—— Address to the Section of Zoology by, 618.

*—— the segmentation and early developmental stages of the Australian native cat (*Dasyurus*), 649.

HOYLE (W. E.) *on the compilation of an index generum et specierum animalium*, 283.
*—— on the cuttlefishes collected by Prof. Herdman, 644.
HUDSON (Prof.) *on the teaching of elementary mathematics*, 473.
HUDSON (R. W. H. T.), matrix notation in the theory of screws, 528.
—— and Prof. BROMWICH, the discriminant of a family of curves or surfaces, 526.
Human cerebral cortex, some new features in the intimate structure of the, by J. Turner, 781.
HUMPHREY (H. A.), recent progress in large gas-engines, 729.
HUNT (A. R.), the evidence of the hydro-thermal metamorphism of the schists of South Devon, 613.
HUNTER (C. F.) *on an ethnological survey of Canada*, 353.
HUTCHINS (Miss B. L.) *on the economic effect of legislation regulating women's labour in Birmingham*, 296.
—— history of the regulation of home work, 1864–1901, 706.
Huygens' construction, an improvement upon, Dr. G. J. Stoney on, 539.
Hydro-aromatic compounds with single nucleus, by Dr. A. W. Crossley, 120.
*Hydrogen and helium, the positions of, in relation to the earth's atmosphere, by Prof. G. H. Bryan, 556.
*Hydrolysis of glycogen, by Dr. W. A. Osborne and S. Zobel, 780.
Hydrothermal metamorphism of the schists of South Devon, A. R. Hunt on the evidence of the, 613.
Hyndman (H. H. F.) on equations of state, 535.

Index generum et specierum animalium, report on the compilation of an, 283.
Indian Coronation contingent, measurements of the, by J. Gray, 760.
*Indian Ocean, Prof. W. A. Herdman on his recent expedition to the, 643.
—— on deposits dredged by Professor Herdman in the, by W. E. Hoyle, 644.
—— the plankton of the, I. C. Thompson on, 643.
Initiation ceremonies of the natives of the Papuan Gulf, Rev. J. H. Holmes on the, 752.
Insect fauna of some Irish caves, G. H. Carpenter on the, 657.
Instability of prices in India before 1861, Prof. T. Morison on the, 704.
*International investigation of the North Sea, W. Garstang on the, 641.
—— certain objections to, by Dr. D. Noël Paton, 641.
Iodine-containing compounds, the colour of, by Miss Ida Smedley, 582.
Ireland, preliminary list of the minerals occurring in, by H. J. Seymour, 598.
—— the structure of, Prof. G. A. J. Cole on, 609.
—— the bird fauna of, as affected by its geography, by R. J. Ussher, 658.
—— the peat-bogs of, by Prof. T. Johnson, 684.
—— a sketch of the linen industry of, by Sir R. Lloyd Patterson, 701.
—— the effects on, of the adoption of free trade by the United Kingdom, by B. Allen, 703.
—— the depopulation of: its causes and economic results, by J. H. Edgar, 705.
—— the increase of consumption in, by R. Brown, 709.
—— the rainfall of, by Dr. H. R. Mill, 732.
*—— water power in, by F. J. Dick, 733.
*—— intermediate education in, by R. M. Jones, 846.
*——, ——, by Rev. Father Murphy, 846.
*—— the relation of technical instruction to industrial development in, by T. P. Gill, 847.
*—— the North-east of, investigations into the glacial drifts of, Madame Christen on, 694.
——, ——, the composition of the flora of, by R. Lloyd Praeger, 815.
Irish caves, report on the exploration of: the Kesh caves, co. Sligo, 247.
—— the insect fauna of some, G. H. Carpenter on, 657.
*Irish education, recent reforms in, Dr. W. J. M. Starkie on, 844.
Irish flora, geographical plant-groups in the, by R. Lloyd Praeger, 683.
IRVINE (Dr. J. C.) and T. PURDIE, the alkylation of sugars, 583.
Isomeric naphthalene derivatives, report on, 176.
*Isomerisation, a new method of causing, by Prof. R. Meldola, 587.
Isomorphous sulphonic derivatives of benzene, third report on, 180.

*JACKSON (H.) and Prof. J. R. GREEN on the germination of fatty seeds, 804.
Japanese 'bokū-to,' two, E. S. Hartland on, 767.
JAPP (Prof. F. R.) *on the relation between the absorption spectra and chemical constitution of organic substances*, 99.
JOHNSON (Prof. T.), the peat-bogs of Ireland, 684.
JOHNSTON (T. N.), the survey of the freshwater lakes of the British Isles, 680.

JOLY (J.) on the viscous fusion of rock-forming minerals, 602.

JONES (Rev. E.) *on the movements of underground waters of North-west Yorkshire*, 224.

*JONES (R. M.), intermediate education in Ireland, 846.

Jordan Valley, the, by Prof. W. Libbey, 680.

JUDD (Prof. J. W.) *on seismological investigation*, 59.

—— *on the coral reefs of the Indian region*, 284.

Jupiter, Uranus and Vesta, spectrograms of, by P. Lowell, 555.

KELTIE (Dr. J. Scott) *on terrestrial surface-waves and wave-like surfaces*, 285.

KELVIN (Lord) *on practical electrical standards*, 53.

—— *on comparing and reducing magnetic observations*, 58.

—— *on seismological investigation*, 59.

—— *on the B.A. screw gauge*, 350.

—— on an animal thermostat, 543.

KENDALL (Prof. P. F.) *on life-zones in the British carboniferous rocks*, 210.

—— *on the movements of underground waters of North-west Yorkshire*, 224.

—— *on the erratic blocks of the British Isles*, 252.

—— on the Brockrams of the Vale of Eden and the evidence they afford of an inter-Permian movement of the Pennine faults, 604.

KERR (Prof. J. Graham) *on the coral reefs of the Indian region*, 284.

—— the early development of muscles and motor nerves in *Lepidosiren*, 655.

Kesh caves, co. Sligo, report on the exploration of the, 247.

Khami ruins, near Bulawayo, Rhodesia, F. P. Mennell on the, 769.

KIDSTON (R.) *on the registration of type specimens of British fossils*, 210.

—— *on life-zones in the British carboniferous rocks*, 210.

—— *on the collection of photographs of geological interest*, 229.

KIMMINS (Dr. C. W.) *on the conditions of health essential to the carrying on of the work of instruction in schools*, 483.

—— the subjects to be taught as science in schools, and the order in which they should be taken, 844.

*KINGSBURY (J. E.), the future of the telephone in the United Kingdom, 734.

*KINSKY (A. M.) and Prof. W. B. MORTON on continuous motion produced by vibrations, 511.

Knossos in Crete, report on explorations at, 466.

KNOTT (Prof. C. G.) *on seismological investigation*, 59.

KNOWLES (W. J.) on objects of the plateau kind from the interglacial gravels of Ireland, 756.

—— on stone axe factories near Cushendall, co. Antrim, 757.

—— the manufacture of arrow- and spear-heads, 758.

KNUBLEY (Rev. E. P.) *on working out the details of the observations on the migration of birds*, 273.

KYNASTON (H.) on the volcanic rocks of Glencoe, and their relation to the granite of Ben Cruachan, 602.

LAMPLUGH (G. W.) *on life-zones in the British carboniferous rocks*, 210.

—— *on the Kesh caves, co. Sligo*, 247.

*Language, a universal, by Sir F. J. Bramwell, 847.

LANKESTER (Prof. E. Ray) *on the occupation of a table at the Zoological Station at Naples*, 259.

—— *on investigations made at the Marine Biological Laboratory, Plymouth*, 271.

—— *on the micro-chemistry of cells*, 470.

Lapwing (Vanellus vulgaris), *the migrations of the, W. Eagle Clarke on*, 277.

LARMOR (Dr. J.) *on the teaching of elementary mathematics*, 473.

—— on the application of the method of entropy to radiant energy, 546.

—— on the relation of voltaic potential differences to temperature, 546.

LAUDER (A.) *on the relation between the absorption spectra and chemical constitution of organic substances*, 99.

—— *on the absorption spectra of phloroglucinol and some of its derivatives*, 99.

LAURIE (Prof. M.) *on investigations in the laboratory of the Marine Biological Association of the West of Scotland at Millport*, 272.

LAYARD (Miss N. F.) on a recent discovery of palæolithic implements in plateau gravels of Ipswich, 759.

Lead, the action of distilled water upon, by Prof. F. Clowes, 576.

LEBOUR (Prof. G. A.) *on life-zones in the British carboniferous rocks*, 210.

Leiper (R. T.) on an acœlous turbellarian inhabiting the common heart urchin, 652.

Lepidosiren, the early development of muscles and motor nerves in, by Prof. J. Graham Kerr, 655.

*LETTS (Prof. E. A.) on the corrosion of copper by sea-water, and on the detection of traces of impurity in the commercial metal, 576.

*Letts (Prof. E. A.) on determinations of atmospheric carbonic anhydride made on board the 'Discovery,' 587.

*—— and W. Caldwell on experiments to ascertain the amount of carbonic anhydride absorbed from the sea-water by air, 576.

*—— and J. S. Totton on the absorption of ammonia from water by algæ, 587.

Levelling staff, a direct reducing, by G. W. Herdman, 733.

Lewis (A. L.) *on the age of stone circles*, 455.

Lia Fáil of Tara, the, and election of kings by augury, E. S. Hartland on, 766.

Libbey (Prof. W.), the Jordan valley, 680.

—— Petra, 681.

*—— with Lieut. Peary in Greenland, 687.

Life, the suspension of, at low temperatures, by Dr. A. Macfadyen and S. Rowland, 804.

Life-zones in the British carboniferous rocks, report on, 210.

Light, the resolution of, into undulations of flat wavelets, how to apply to the investigation of optical phenomena, by Dr. G. J. Stoney, 539.

Linen industry of Ireland, a sketch of the, by Sir R. Lloyd Patterson, 701.

Lister (J. J.) *on the coral reefs of the Indian region*, 284.

Liveing (Capt. C. H.), Major W. E. Edwards, and Prof. W. R. Hodgkinson, the reduction of some metallic chlorides by calcium carbide, 585.

Liveing (Prof. G. D.) *on wave-length tables of the spectra of the elements and compounds*, 137.

Localisation of industry, Rev. W. Cunningham on the, 695.

Lockyer (Sir J. N.) *on wave-length tables of the spectra of the elements and compounds*, 137.

Lodge (Prof. A.) *on the teaching of elementary mathematics*, 473.

Lodge (Sir O. J.) *on practical electrical standards*, 53.

—— *on the teaching of elementary mathematics*, 473.

Lolos, the, and other tribes of Western China, Augustine Henry on, 765.

Lomas (J.) *on the erratic blocks of the British Isles*, 252.

—— on deposits dredged by Prof. Herdman in the Indian Ocean, 644.

Lomax (J.) on some new features in relation to *Lyginodendron oldhamium*, 809.

Lomax (James) on the occurrence of the nodular concretions (coal balls) in the lower coal measures, 811.

Lonicera, the morphology of the flowers in certain species of, E. A. N. Arber on, 816.

Love (Prof.) *on the teaching of elementary mathematics*, 473.

Lovett (E.) on tallies, 767.

Lowell (P.), a standard scale for telescopic observations, 553.

—— expedition for ascertaining the best location of observatories, 554.

—— spectrograms of Jupiter, Uranus, and Vesta, 555.

Luminosity and the kinetic theory, J. E. Burke on, 549.

Luminous bacteria, J. E. Barnard and Prof. A. Macfadyen on, 801.

Lunar surface, possible changes on the, by S. A. Saunder, 551.

Lut, the great desert of Persia known as the, Major P. M. Sykes on, and on the Helmand Delta, 677.

Lyginodendron oldhamium, some new features in relation to, J. Lomax on, 809.

Macalister (Prof. A.) *on the coral reefs of the Indian region*, 284.

—— *on anthropometric investigations among the native troops of the Egyptian army*, 350.

—— *on a pigmentation survey of the school children of Scotland*, 352.

—— *on explorations at Knossos in Crete*, 466.

Macalister (R. A. S.) on a prehistoric cemetery-cave in Palestine, 768.

Macallum (Prof. A. B.) *on the micro-chemistry of cells*, 470.

MacBride (Prof. E. W.), the development of the common sea-urchin (*Echinus esculentus*), 647.

MacDonald (Mrs. J. R.) *on the economic effect of legislation regulating women's labour*, 286.

Macfadyen (Prof. A.) and J. E. Barnard on luminous bacteria, 801.

——, and S. Rowland on the suspension of life at low temperatures, 804.

McHenry (A.) *on the Kesh caves, co. Sligo*, 247.

McIntosh (Prof. W. C.) *on the occupation of a table at the Zoological Station at Naples*, 259.

—— on British fisheries' investigations and the international scheme, 638.

McKendrick (Prof. J. G.) *on the work of the mammalian heart*, 470.

Mackenzie (Prof. J. J.) *on the micro-chemistry of cells*, 470.

Mackie (Dr. Wm.), the conditions under which manganese dioxide has been deposited in sedimentary rocks, as illustrated by the Elgin sandstones, 606.

MACKIE (Dr. Wm.) the so-called 'fossil' water of sedimentary strata, as illustrated by the sandstones of the Moray Firth basin, 608.

MCLACHLAN (R.) *on the compilation of an index generum et specierum animalium*, 283.

MCLAREN (Lord) *on meteorological observations on Ben Nevis*, 93.

MACLAREN (Norman) *on trematodes and cestodes parasitic on fishes*, 260.

MCMAHON (Lieut.-Gen. C. A.), Address to the Section of Geology by, 589.

MACMAHON (Major) *on the teaching of elementary mathematics*, 473.

MACRITCHIE (David), underground dwellings in the British Isles, 755.

Magnetic detectors in space telegraphy, by Prof. Ernest Wilson, 547.

Magnetic observations, comparing and reducing, report on, 58.

Magnetic observations at Falmouth, report on, 75.

*Magnetic testing instrument, a new, by F. Holden, 734.

MAGNUS (Sir P.) *on the teaching of science in elementary schools*, 481.

*Malay Peninsula, flower-like insects from the, by Nelson Annandale, 649.

*—— protective resemblance in the, H. C. Robinson on, 650.

:—— the wild and civilised races of the, Nelson Annandale and H. C. Robinson on, 766.

Malays of Patani, human souls and ghosts among the, by Nelson Annandale, 752.

MALLOCK (A.) *on the resistance of road vehicles to traction*, 314.

Mammalian heart, the work of the, report on, 470.

Manganese dioxide, the conditions under which it has been deposited in sedimentary rocks, as illustrated by the Elgin sandstones, by Dr. W. Mackie, 606.

Map-colouring, Prof. A. C. Dixon on, 525.

MARCHANT (Dr. E. W.), a graphical method of determining the discharge curve of a condenser through a variable self-induction, 548.

Marine Biological Association of the West of Scotland, investigations in the laboratory of the, at Millport, report on, 272.

Marine Biological Laboratory, Plymouth, report on the occupation of a table at the, 271.

Marine fauna of the boulder clay, J. Wright on the, 598.

*MARKHAM (Sir Clements) on Capt. Sverdrup's north polar expedition, 687.

MARR (J. E.) *on life-zones in the British carboniferous rocks*, 210.

MARR (J. E.) *on the movements of underground waters of North-west Yorkshire*, 224.

—— *on the erratic blocks of the British Isles*, 252.

*MASTERMAN (Dr. A. T.) the relationships of the larva to the adult in the starfish, 647.

**Mastodon angustidens*, Dr. C. W. Andrews on the tusks and skull of, 599.

—— Dr. C. W. Andrews on a diagram of the skull of the, 654.

Mathematical and Physical Science, Address by Prof. J. Purser to the Section of, 499.

*Mathematics, the teaching of, discussion on, 848.

——, *elementary, report on the teaching of*, 473.

——, ——, the teaching of, A. W. Siddons on, 848.

Matrix notation in the theory of screws, by R. W. H. T. Hudson, 528.

MATTHAEI (Miss G. L. C.), the effect of temperature on carbon dioxide assimilation, 805.

MATTHEY (G.) *on practical electrical standards*, 53.

*MAVOR (H. A.), the making of a dynamo, 736.

MAVOR (Prof. J.) *on an ethnological survey of Canada*, 353.

*MAY (Dr. W. Page) on the innervation and movements of the stomach, 780.

*—— the nervous system of the camel, 782.

*Medullated nerve, the indefatigability of, by Prof. F. Gotch, 784.

MELDOLA (Prof. R.) *on seismological investigation*, 59.

—— *on the age of stone circles*, 455.

*—— a new method of causing isomerisation, 587.

—— *on the work of the Corresponding Societies Committee*, 857.

MENNELL (F. P.) on the Khami ruins, near Bulawayo, Rhodesia, 709.

Mental and moral characteristics of the people of Ulster, Dr. W. Graham on the, 762.

Mercury, the variation of the specific heat of, with temperature, Dr. H. T. Barnes and H. L. Cooke on, 530.

Metallic chlorides, the reduction of some, by calcium carbide, by Major W. E. Edwards, Capt. C. H. Liveing, and Prof. W. R. Hodgkinson, 585.

Meteorological observations on Ben Nevis, report on, 93.

Meteorology, radiation in, by Dr. W. N. Shaw, 541.

Methylmorphimethine, a fourth, J. Hawthorne on, 582.

Miadesmia membranacea (Bertrand), a lycopodiaceous plant from the coal measures, the seed-like fructification of, by Miss M. Benson, 808.

MIALL (Prof. L. C.) *on botanical photographs*, 471.

—— *on the conditions of health essential to the carrying on of the work of instruction in schools*, 483.

Micro-chemistry of cells, report on the, 470.

*Middle Cambrian trilobites, &c., of Mount Stephen, British Columbia, Dr. H. Woodward on the, 598.

MIERS (Prof. H. A.) *on isomorphous sulphonic derivatives of benzene*, 180.

Migration of birds, observations on the, 1880–1887, *fifth interim report on working out the details of*, 273.

MILL (Dr. H. R.) *on the investigation of the upper atmosphere by means of kites*, 77.

—— the motives of Antarctic exploration, 685.

—— the rainfall of Ireland, 732.

MILNE (J.) *on seismological investigation*, 59.

—— world-shaking earthquakes in relation to volcanic eruptions in the West Indies, 682.

*Mimicry and natural selection, discussion on, 661.

MINCHIN (Prof.) *on the teaching of elementary mathematics*, 473.

—— a new receiver for Hertzian oscillations, 547.

—— the neglect of English grammar, 847.

Minerals occurring in Ireland, preliminary list of the, by H. J. Seymour, 598.

*MINOT (Prof. C. S.) on the significance of the embryonic cell, 658.

MONCKTON (Horace W.) on the valleys at the head of the Hardanger Fjord, Norway, 612.

—— a summary of the principal changes in South-east England during Pliocene and more recent times, 616.

Monkey, the relative effects of section of the pyramidal tracts and anterior columns in the, Prof. E. A. Schäfer on, 780.

MORGAN (Dr. G. T.) *on our present knowledge of aromatic diazo-compounds*, 181.

MORISON (Prof. T.), the instability of prices in India before 1861, 704.

Morphology of sporangial integuments, W. C. Worsdell on the, 812.

Morphology of the araucarieæ, Miss S. O. Ford on the, 810.

Morphology of the flowers in certain species of *Lonicera*, E. A. N. Arber on the, 816.

Morphology of the seed and seedling of *Torreya*, Prof. F. W. Oliver and Miss E. Chick on the, 814.

MORRISON (Walter) *on the movements of underground waters of North-west Yorkshire*, 224.

*MORTON (Prof. W. B.) and W. HAWTHORN, motion of a detached thread of liquid in a capillary tube, 511.

*—— and A. M. KINSKY on continuous motion produced by vibrations, 511.

*—— and T. B. VINYCOMB on the vibrations of a plucked string, 511.

*Motion of a detached thread of liquid in a capillary tube, by Prof. W. B. Morton and W. Hawthorn, 511.

*Motion through the ether, does it cause double refraction? by Lord Rayleigh, 546.

MOTT (Dr. F. W.) and Prof. W. D. HALLIBURTON, regeneration of nerves, 782.

*MUIR (T.) on a practical rule for finding the perimeter of an ellipse, 529.

MUIRHEAD (Dr. A.) *on practical electrical standards*, 53.

Municipal policy and State control, by P. Ashley, 700.

Municipal trading, by Hon. R. P. Porter, 699.

MUNRO (Dr. R.) *on the age of stone circles*, 455.

*MURPHY (Rev. Father), intermediate education in Ireland, 846.

MURRAY (Sir John) *on meteorological observations on Ben Nevis*, 93.

—— *on investigations in the laboratory of the Marine Biological Association of the West of Scotland at Millport*, 272.

MYERS (Dr. C. S.) *on anthropometric investigations among the native troops of the Egyptian army*, 350.

—— dependence of pitch of minute closed pipes on wind pressure, 537.

*—— on a method of radial craniometry, 760.

*—— determination of the least perceptible tone-difference among the people of the Torres Straits and of Scotland, 781.

MYRES (J. L.) *on the collection of anthropological photographs*, 449.

—— *on the Roman fort at Gellygaer*, 450.

—— *on the Silchester excavation*, 453.

—— *on explorations at Knossos in Crete*, 426.

*Nagas, the ethnography of the, Dr. W. H. Furness on, 770.

NALDER (F. H.), light aluminium tubes, 551.

Naples Zoological Station, report on the occupation of a table at the, 259.

Nature's economics, by Miss H. Blackburn, 708.

*Nebula surrounding Nova Persei, discussion on the, 521.

Nerves, regeneration of, by Prof. W. D. Halliburton and Dr. F. W. Mott, 782.

*Nervous system of the camel, the, by Dr. W. Page May, 782.

NEVILLE (F. H.) *on the nature of alloys*, 175.

NEWTON (Prof. A.) *on working out the details of the observations on the migration of birds*, 273.

—— *on the zoology of the Sandwich Islands*, 284.

Newtonian potential, Prof. A. C. Dixon on the, 526.

Nodular concretions (coal balls) in the lower coal measures, James Lomax on the occurrence of the, 811.

*North Sea, the international investigation of the, by W. Garstang, 641.

—— —— certain objections to, by Dr. D. Noël Paton, 641.

*Nova Persei, the nebula surrounding, discussion on, 521.

*Nucleolus, the function of the, by H. Wager, 818.

Observatories, the best location of, expedition for ascertaining, by P. Lowell, 554.

Ocean currents, material-bearing, the direction and velocity of, with description of an apparatus recently designed for estimating the same, by R. G. Allanson-Winn, 737.

OLDHAM (R. D.) *on seismological investigation*, 59.

*OLIVER (Prof. F. W.) on ancient and modern seeds, 813.

—— and Miss E. CHICK on the morphology of the seed and seedling of *Torreya*, 814.

Onuphididæ (Polychæta), on the habits of the, and on the internal structures with which they fortify their homes, by A. T. Watson, 652.

O'REILLY (P. J.) on a survival of certain pagan sepulchral symbols on early Christian monuments in Ireland, 769.

*OSBORNE (Dr. W. A.), the pigments of ox bile, 784.

*—— and S. ZOBEL, the hydrolysis of glycogen, 780.

*Ox bile, the pigments of, by Dr. W. A. Osborne, 784.

Pagan sepulchral symbols, the survival of, on early Christian monuments in Ireland, P. J. O'Reilly on, 769.

*Palæokastro in Eastern Crete, R. C. Bosanquet on excavations at, 770.

Palæolithic flint implements, a recent find of, at Knowle, Wiltshire, W. and Dr. W. A. Cunnington on, 759.

Palæolithic implements in plateau gravels of Ipswich, a recent discovery of, Miss N. F. Layard on, 759.

Papuan Gulf, the initiation ceremonies of the natives of the, by Rev. J. H. Holmes, 752.

*Paralysis of convergence, a case of, by Dr. Cyril Shaw, 781.

Parietal bone in primates, the connection of the anterior inferior angle of the, by Prof. R. J. Anderson, 651.

*PARSONS (Hon. C. A.), steam turbines, 730.

PATON (Dr. D. Noël), certain objections to the proposed scheme of international investigations of the North Sea, 641.

PATTERSON (J. Hume) on the cause of salmon disease, 647.

PATTERSON (Sir R. Lloyd), a sketch of the linen industry of Ireland, 701.

PEACH (B. N.) *on life-zones in the British carboniferous rocks*, 210.

*Pearl oyster banks of the Gulf of Manaar, Prof. W. A. Herdman on his work on the, 643.

*Peary, Lieut., with, in Greenland, by Prof. W. Libbey, 687.

Peat-bogs of Ireland, the, by Prof. T. Johnson, 684.

Pendleside limestones, a list of the fish fauna of the, by E. D. Wellburn, 222.

PENHALLOW (Prof. D. P.) *on an ethnological survey of Canada*, 353.

Perforated stone amulets, F. T. Elworthy on, 767.

*Perimeter of an ellipse, a practical rule for finding the, T. Muir on, 529.

PERKIN (Prof. W. H.) *on statistics concerning the training of chemists employed in English chemical industries*, 97.

PERRY (Prof. J.) *on practical electrical standards*, 53.

—— *on seismological investigation*, 59.

—— *on the teaching of elementary mathematics*, 473; *suggested schedule of experimental geometry*, 479.

—— Address to the Section of Engineering by, 711.

*—— a note on gas-engine explosions, 737.

Persia, Southern, the geography of, as affecting its history, Major P. M. Sykes on, 677.

PETAVEL (J. E.), some experiments on radiation and absorption: a preliminary study for a standard of light, 534.

Petavel's recording gauge applied to ordnance and small arms, by Capt. J. Bruce-Kingsmill, 538.

Petra, by Prof. W. Libbey, 681.

PETRIE (Prof. Flinders) *on the collection of anthropological photographs*, 449.

Phloroglucinol and some of its derivatives, the absorption spectra of, by Profs. W. N. Hartley and J. J. Dobbie and A. Lauder, 99.

Photographs of anthropological interest, interim report on the collection of, 449.

Photographs of geological interest, thirteenth report on the collection of, 229.

Physical and Mathematical Science, Address by Prof. J. Purser to the Section of, 499.

Physics of the flow of fluids in plant stems, some inquiry into the, by Prof. R. J. Anderson, 817.

Physiology, Address by Prof. W. D. Halliburton to the Section of, 771.

Pigmentation survey of the school children of Scotland, report on a, 352.

Pigmentation survey of school children in Ireland, a plea for a, by J. F. Tocher, 865.

Pilot whale (*Globiocephalus melas*), Prof. R. J. Anderson on a specimen of the, 650.

Pitch of minute closed pipes, dependence of, on wind pressure, by Dr. C. S. Myers, 537.

*Pituitary extracts, the diuretic action of, Prof. E. A. Schäfer on, 780.

Plankton of the Indian Ocean, I. C. Thompson on the, 643.

Plants, the respiration of, report on, 472.

Plateau objects from the interglacial gravels of Ireland, W. J. Knowles on, 756.

PLUMMER (W. E.) *on seismological investigation*, 59.

Pluperfect numbers, Lt.-Col. A. Cunningham on, 528.

Plymouth, the marine biological laboratory at, report on the occupation of a table at, 271.

p-*nitroso-phenol, quinone, and similarly derived substances, the curves of molecular vibrations of, report on*, 107.

Podostemaceæ, the dorsiventrality of the, with reference to current views on evolution, J. C. Willis on, 806.

Point-groups, the theory of, report on, 81.

*Polygordius and Eupomatus, early development of the head-kidney in, C. Shearer on, 661.

POPE (W. J.) *on isomorphous sulphonic derivatives of benzene*, 180

Population of England and Wales during the eighteenth century, the, by Prof. E. C. K. Gonner, 706.

PORTER (J.) on some features of the Cork river-valleys, 684.

PORTER (Hon. R. P.), municipal trading, 699.

Post-glacial deposits of the Belfast district, R. Lloyd Praeger on the, 611.

*POULTON (Prof. E. B.) on the habits of the predaceous flies of the family of Asilidæ, 647.

POYNTING (Prof. J. H.) *on seismological investigation*, 59.

Practical instruction, the introduction of, into Irish national schools, by W. M. Heller, 845.

PRAEGER (R. Lloyd) *on the Kesh caves, co. Sligo*, 247.

—— the post-glacial deposits of the Belfast district, 611.

—— geographical plant-groups in the Irish flora, 683.

—— the composition of the flora of the north-east of Ireland, 815.

PREECE (Sir W. H.) *on practical electrical standards*, 53.

—— *on magnetic observations at Falmouth*, 75.

—— *on the B.A. screw gauge*, 350.

Prehistoric cemetery-cave in Palestine, R. A. S. Macalister on a, 768.

Prehistoric remains, a plea for an Ordnance map index of, by C. H. Read, 870.

PRICE (L. L.) *on the economic effect of legislation regulating women's labour*, 286.

PRICE (W. A.) *on the B.A. screw gauge*, 350.

Primitive man, a study in the psychology of, by A. Amy Bulley, 764.

Primitive site near Groomsport, co. Down, the excavation of a, R. M. Young on, 759.

*Protective resemblance in the Malay Peninsula, H. C. Robinson on, 650.

Psychology of primitive man, a study in the, by A. Amy Bulley, 764.

Pteridophyta, sporangiophores as a clue to affinities among, by Dr. D. H Scott, 810.

PURDIE (T.) and Dr. J. C. IRVINE, the alkylation of sugars, 583.

PURSER (Prof. J.), Address to the Section of Mathematical and Physical Science, 499.

Quinone, p-*nitroso-phenol and similarly derived substances, the curves of molecular vibrations of, report on*, 107.

Radiation and absorption, some experiments on, by J. E. Petavel, 534.

Radiation in meteorology, by Dr. W. N Shaw, 541.

Rainfall of Ireland, the, by Dr. H. R Mill, 732.

*Ramsay and Young's law for the comparison of vapours at equal pressures, Prof. J. D. Everett on the graphical representation of, 537.

*Range-finder, the infantry, experiences with, in the South African war, by Prof. G. Forbes, 736.

Rayleigh (Lord) *on practical electrical standards*, 53.

*—— on the question as to the accurate conservation of weight in chemical reactions, 511.

*—— does motion through the ether cause double refraction? 546.

*Rayworth (J. S.), the prevention of smoke, 736.

Read (C. H.) *on the collection of anthropological photographs*, 449.

—— *on the age of stone circles*, 455.

—— *on the work of the Corresponding Societies Committee*, 851.

—— a plea for an Ordnance map index of prehistoric remains, 870.

Reid (A. S.) *on the collection of photographs of geological interest*, 229.

Reid (Clement) *on seismological investigation*, 59.

Relative apparent motions of bright and faint stars, Prof. H. H. Turner on the, 552.

Rennie (J.) *on practical electrical standards*, 53.

Resistance of road vehicles to traction, report on the, 314.

Respiration of plants, report on the, 472.

*Retina, the functions of the rods and cones of the, by Dr. F. W. Edridge-Green, 780.

Rhys (Prof. J.) *on the Roman fort at Gellygaer*, 450.

Richardson (Nelson) *on seismological investigation*, 59.

Ridgeway (Prof. W.) *on explorations at Knossos in Crete*, 466.

Ridgeway fault, relative movements of the strata at, H. Darwin on, 75.

Rigg (E.) *on the B.A. screw gauge*, 350.

Rivers (Dr. W. H. R.) *on a pigmentation survey of the school children of Scotland*, 352.

*Robb (A. A.), a theorem in determinants, 530.

*Roberts (Dr. Isaac), illustrations obtained by photography of the evolution of stellar systems, 541.

Roberts-Austen (Sir W. C.) *on practical electrical standards*, 53.

* Robinson (H. C.) on protective resemblance in the Malay Peninsula, 650.

—— and N. Annandale on the wild and civilised races of the Malay Peninsula, 766.

Rock-forming minerals, the viscous fusion of, J. Joly on, 602.

Rockall, the islet of, by Rev. W. S. Green, 686.

Roman fort at Gellygaer, report on the, 450.

Roscoe (Sir H. E.) *on wave-length tables of the spectra of the elements and compounds*, 137.

—— *on the teaching of science in elementary schools*, 481.

Roth (H. Ling) *on the collection of anthropological photographs*, 449.

Rowland (S.) and Dr. A. Macfadyen on the suspension of life at low temperatures, 804.

Rücker (Sir A. W.) *on practical electrical standards*, 53.

—— *on comparing and reducing magnetic observations*, 58.

—— *on magnetic observations at Falmouth*, 75.

—— *on the teaching of elementary mathematics*, 473.

Rudler (F. W.) *on the work of the Corresponding Societies Committee*, 851.

Russell (R.) *on the teaching of elementary mathematics*, 473.

Ryder (Capt. C. H. D.), Yünnan, 678.

Sakhalin, the island of, and its inhabitants, by C. H. Hawes, 684.

Salmon disease, the cause of, J. H. Patterson on, 647.

Salomons (Sir D.) *on the resistance of road vehicles to traction*, 314.

Samsu, a fermented drink of Eastern Asia, and its characteristic fungus, by B. T. B. Barker, 818.

Sandwich Islands, the zoology of the, twelfth report on, 284.

Saunder (S. A.), possible changes on the lunar surface, 551.

Scales in the cod, the structure of the, Dr. H. W. M. Tims on, 660.

Scales of fishes as an index of age, J. S. Thomson on the, 642.

Schäfer (Prof. E. A.) *on the microchemistry of cells*, 470.

*—— on the diuretic action of pituitary extracts, 780.

—— on the relative effects of section of the pyramidal tracts and anterior columns in the monkey, 780.

Scharff (Dr. R. F.) *on the Kesh caves, co. Sligo*, 247.

—— on the Atlantis problem, 653.

School children of Scotland, report on a pigmentation survey of the, 352.

Schuster (Prof. A.) *on practical electrical standards*, 53.

—— *on comparing and reducing magnetic observations*, 58.

SCHUSTER (Prof. A.) *on magnetic observations at Falmouth*, 75.

—— *on wave-length tables of the spectra of the elements and compounds*, 137.

*—— on the prevention of a deposit of dew on the lenses of a projecting lantern, 511.

—— Address to the Department of Astronomy and Cosmical Physics, 512.

Science, the teaching of, in elementary schools, report on, 481.

*Science of the workshop, the, by W. Taylor, 735.

SCLATER (Dr. P. L.) *on the compilation of an index generum et specierum animalium*, 283.

—— *on the zoology of the Sandwich Islands*, 284.

SCOTT (Dr. D. H.), sporangiophores as a clue to affinities among pteridophyta, 810.

SCOTT (Mrs. Rina), the movements of the flower-buds of *Sparmannia africana*, 803.

SCOTT (Dr. W. R.), the position of economics and the applied sciences in a proposed university training of persons intended for a commercial life, 696.

SCOTT-ELLIOT (Prof. G. F.) *on botanical photographs*, 471.

Scottish national antarctic expedition, W. S. Bruce on the, 686.

Screw gauge, the British Association, report on, 350.

Screws, matrix notation in the theory of, by R. W. H. T. Hudson, 528.

Sea-urchin, the common (*Echinus esculentus*), the development of, by Prof. E. W. MacBride, 647.

Seals, a hitherto unrecorded element in the occipital bone of, Prof. Cleland on, 646.

SEDGWICK (A.) *on the occupation of a table at the Zoological Station at Naples*, 259.

—— *on investigations made at the Marine Biological Laboratory, Plymouth*, 271.

—— *on the coral reefs of the Indian region*, 284.

Sedimentary deposits, the original form of, Rev. J. F. Blake on, 603.

Seeds, resistance of, to high temperatures, by Dr. H. H. Dixon, 805.

*—— ancient and modern, Prof. F. W. Oliver on, 813.

SEELEY (Prof. H. G.) *on the registration of type specimens of British fossils*, 210.

—— fossils from cretaceous strata in the Salt Range of India, 604.

Seismological investigation, seventh report on, 59.

SENNETT (A. R.) *on the resistance of road vehicles to traction*, 314.

*SEWARD (A. C.) and E. N. ARBER, fossil *Nipa* fruits from Belgium, 808.

SEYMOUR (H. J.), preliminary list of the minerals occurring in Ireland, 598.

SHARP (Dr. D.) *on the zoology of the Sandwich Islands*, 284.

*SHAW (Dr. Cecil) and Prof J. SYMINGTON, demonstration of Edinger's apparatus for higher magnifications and stronger light, 784.

*SHAW (Dr. Cyril), a case of paralysis of convergence, 781.

SHAW (Judge), a British Zollverein, or preferential tariffs within the British Empire, 702.

SHAW (Dr. W. N.) *on practical electrical standards*, 53.

—— *on the investigation of the upper atmosphere by means of kites*, 77.

—— radiation in meteorology, 541.

*SHEARER (C.) on early development of the head-kidney in Polygordius and Eupomatus, 661.

SHERRINGTON (Prof. C. S.) *on the conditions of health essential to the carrying on of the work of instruction in schools*, 483.

Shipping combinations, by Dr. B. W. Ginsburg, 698.

SIDDONS (A. W.) on the teaching of elementary mathematics, 848.

Silchester excavation, report on the, 453.

Silurian area of N.E. Ireland, the fossils of the, R. Clark on, 599.

*Skull modified by acromegaly, Prof. A. F. Dixon on a, 753.

SMART (Prof. W.) *on the economic effect of legislation regulating women's labour*, 286.

SMEDLEY (Miss Ida), the colour of iodine-containing compounds, 582.

SMITH (Miss A. L.), a disease of the gooseberry, with notes on *Botrytis* and *Sclerotium*, 816.

SMITH (E. A.) *on the zoology of the Sandwich Islands*, 284.

SMITH (E. Shrapnell) *on the resistance of road vehicles to traction*, 314.

*SMITH (M. H.), the importance of minor details in engineering work, 735.

SMITHELLS (Prof. A.) *on the movements of underground waters of North-west Yorkshire*, 224.

—— *on the teaching of science in elementary schools*, 481.

*Smoke, the prevention of, by J. S. Rayworth, 736.

Smokeless combustion of bituminous fuel, W. H. Booth on the, 736.

Solar radiation recorder, a new, by Dr. W. E. Wilson, 521.

*Solignac boiler, W. H. Booth on the, 736.

SOLLAS (Prof. W. J.) *on the erratic blocks of the British Isles*, 252.

SOMERVILLE (Alex.) *on investigations in the laboratory of the Marine Biological Association of the West of Scotland at Millport*, 272.

Souterrains, some Ulster, W. J. Fennell on, 753.

Sparmannia africana, the movements of the flower-buds of, by Mrs. Rina Scott, 803.

Spear- and arrow-heads, the manufacture of, by W. J. Knowles, 758.

Spectra of the elements and compounds, wave-length tables of the, report on, 137.

Spectrograms of Jupiter, Uranus, and Vesta, by P. Lowell, 555.

Sporangial integuments, the morphology of, by W. C. Worsdell, 812.

Sporangiophores as a clue to affinities among pteridophyta, by Dr. D. H. Scott, 810.

Sporozoa, the life-history of, H. M. Woodcock on, 271.

Standard analytical methods, the undesirability of establishing, by Bertram Blount, 577.

Standard scale for telescopic observations, P. Lowell on a, 553.

*Starfish, the relationships of the larva to the adult in the, by Dr. A. T. Masterman, 647.

***STARKIE** (Dr. W. J. M.) on recent reforms in Irish education, 845.

Stars, bright and faint, the relative apparent motions of, by Prof. H. H. Turner, 552.

State control and municipal policy, by P. Ashley, 700.

STATHER (J. W.) *on the erratic blocks of the British Isles*, 252.

Statistics and Economic Science, Address by Dr. E. Cannan to the Section of, 688.

*Steam turbines, by Hon. C. A. Parsons, 730.

STEBBING (Rev. T. R. R.) *on the compilation of an index generum et specierum animalium*, 283.

—— *on the work of the Corresponding Societies Committee*, 851.

STEEL (T.) on examples of Australian fauna, 650.

*—— exhibition of some characteristic Australian plants, 802.

*Stellar systems, illustrations obtained by photography of the evolution of, by Dr. I. Roberts, 541.

***STIRLING** (James) on the new geological map of Victoria, 603.

—— on a census of the flora of the Australian Alps, 799.

*Stomach, the innervation and movements of the, Dr. W. Page May on, 780.

Stone axe factories near Cushendall, co. Antrim, W. J. Knowles on, 757.

Stone circles, the age of, report on explorations to ascertain, 455.

STONEY (Dr. G. J.) *on practical electrical standards*, 53.

—— on an improvement upon Huygens' construction, 539.

—— how to apply the resolution of light into undulations of flat wavelets to the investigation of optical phenomena, 539.

STRAHAN (A.) *on life-zones in the British carboniferous rocks*, 210.

STROH (A.) *on the B.A. screw gauge*, 350.

Subjects to be taught as science in schools, the, and the order in which they should be taken, by Dr. C. W. Kimmins, 844.

Subterranean chambers, some ancient, recently discovered at Waddon, near Croydon, G. Clinch on, 754.

SUDBOROUGH (Prof. J. J.) and Dr. W. A. **BONE**, acid esters of methyl succinic acids, 586.

—— and H. **HIBBERT**, compounds of trinitrobenzene with alkylated arylamines, 587.

—— and K. J. **THOMPSON**, action of alkalis on cinnamic acid dibromide and its esters, 587.

Sugars, the alkylation of, by T. Purdie and Dr. J. C. Irvine, 583.

SULTE (B.) *on an ethnological survey of Canada*, 353.

Sun, the uncertainty of our present knowledge of the distance of the, by A. R. Hinks, 555.

Sunspots, minimum, and terrestrial magnetism, by Rev. A. L. Cortie, 522.

Survey of the freshwater lakes of the British Isles, T. N. Johnston on the, 680.

*Sverdrup's, Capt., north polar expedition, Sir Clements Markham on, 687.

SYKES (Major P. M.), the geography of Southern Persia as affecting its history, together with a brief account of the Helmand Delta and the great desert of Persia known as the Lut, 677.

***SYMINGTON** (Prof. J.), exhibition of specimens illustrating physical anthropology, 753.

*—— demonstration on specimens illustrating points in physical anthropology, 770.

*—— and Dr. **CECIL SHAW**, demonstration of Edinger's apparatus for higher magnifications and stronger light, 784.

Synthetical action of enzymes, Dr. E. F. Armstrong on the, 579.

Synthetical researches in the glucoside group, recent, by Dr. E. F. Armstrong, 578.

Tallies, E. Lovett on, 767.

Taylor (W.) _on the B.A. screw gauge_, 350.

*—— the science of the workshop, 735.

*Teachers, the training of, discussion on, 847.

Teall (J. J. H.) _on the collection of photographs of geological interest_, 229.

*—— the drift map of the Dublin area, 602.

*Technical instruction, the relation of, to industrial development in Ireland, by T. P. Gill, 847.

*Telephone, the future of the, in the United Kingdom, by J. E. Kingsbury, 734.

Telescopic observations, a standard scale for, by P. Lowell, 553.

Telluric distribution of the elements in relation to their atomic weights, W. Ackroyd on the, 581.

Temperature, the relation of voltaic potential differences to, Dr. J. Larmor on, 546.

Terrestrial magnetism and minimum sun-spots, by Rev. A. L. Cortie, 522.

Terrestrial surface-waves and wave-like surfaces, second report on, 285.

*Theorem in determinants, a, by A. A. Robb, 530.

Theory of screws, matrix notation in the, by R. W. H. T. Hudson, 528.

Thermostat, an animal, Lord Kelvin on, 543.

Thompson (I. C.) on the plankton of the Indian Ocean, 643.

Thompson (K. J.) and Prof. J. J. Sudborough, action of alkalis on cinnamic acid dibromide and its esters, 587.

Thompson (Prof. S. P.) _on practical electrical standards_, 53.

—— _on the teaching of elementary mathematics_, 473.

—— _on the teaching of science in elementary schools_, 481.

*—— on the specific utilisation of materials in dynamo construction, 735.

Thompson (Prof. W. H.) _on the work of the mammalian heart_, 470.

Thomson (Prof. J. J.) _on practical electrical standards_, 53.

Thomson (J. S.), the scales of fishes as an index of age, 642.

Thornycroft (Sir J. I.) _on the resistance of road vehicles to traction_, 314.

Tiddeman (R. H.) _on the erratic blocks of the British Isles_, 252.

Tilden (Prof. W. A.) _on isomeric naphthalene derivatives_, 176.

Tims (Dr. H. W. M.) on the structure of the scales in the cod, 660.

Tocher (J. F.) _on a pigmentation survey of the school children of Scotland_, 352.

*Tocher (J. F.) on some measurements of Eskimo of Southampton Island, 762.

—— a plea for a pigmentation survey of school children in Ireland, 865.

Todd (J. A.) _on investigations in the laboratory of the Marine Biological Association of the West of Scotland at Millport_, 272.

*Tone-difference, the least perceptible, among the people of Torres Strait and of Scotland, determination of, by Dr. C. S. Myers, 781.

Torreya, the morphology of the seed and seedling of, by Prof. F. W. Oliver and Miss E. Chick, 814.

*Totton (J. S.) and Prof. E. A. Letts on the absorption of ammonia from water by algæ, 587.

Traction, the resistance of road vehicles to, report on, 314.

Training of chemists employed in English chemical industries, statistics concerning the, report on, 97.

*Training of engineers, discussion on the, 847.

*Training of teachers, discussion on the, 847.

Traquair (Dr. R. H.) on the fossil fishes of the Lower Devonian roofing-slate of Gemünden in Germany, 610.

Trematodes and cestodes parasitic on fishes, N. Maclaren on, 260.

*_Trifolium pratense perenne_, two varieties of, by W. Wilson, 819.

Trinitrobenzene, compounds of, with alkylated arylamines, by H. Hibbert and Prof. J. J. Sudborough, 587.

Trusts: from the point of view of economical theory, by Prof. W. Graham, 697.

Tucker (W. T.) _on the erratic blocks of the British Isles_, 252.

Turner (Prof. H. H.) _on seismological investigation_, 59.

—— the relative apparent motions of bright and faint stars, 552.

Turner (J.), some new features in the intimate structure of the human cerebral cortex, 781.

Tylor (Prof. E. B.) _on an ethnological survey of Canada_, 353.

Uganda and the British East Africa Protectorate, colonisation and irrigation in, by R. B. Buckley, 679.

Ulster, the people of, the mental and moral characteristics of, Dr. W. Graham on, 762.

Ulster souterrains, W. J. Fennell on some, 753.

Ultra-Neptunian planet, search for, by Dr. W. E. Wilson, 521.

Ultra-violet therapy, a lens for, by J. W. Gifford, 537.

Underground dwellings in the British Isles, by David MacRitchie, 755.

Underground waters of North-west Yorkshire, the movements of, third report on, 224.

Undulations, regular, produced in a road by the use of sledges, Dr. Vaughan Cornish on, 730.

Unit of heat, on the definition of the, 55.

*Universal language, a, by Sir F. J. Bramwell, 847.

Uranus, Vesta, and Jupiter, spectrograms of, by P. Lowell, 555.

Urea, the decomposition of, by Dr. C. E. Fawsitt, 578.

*Urea in physiological fluids, the estimation of, by J. Barcroft, 784.

USSHER (R. J.) *on the Kesh caves, co. Sligo*, 247.

—— the bird fauna of Ireland as affected by its geography, 658.

Valleys at the head of the Hardanger Fjord, Norway, H. W. Monckton on the, 612.

*Variation phenomena, the interpretation of, by the theory of natural selection, discussion on, 650.

Vascular system of the stem in certain dicotyledonous orders, the nature of, by W. C. Worsdell, 814.

Vehicle wheel, a new elastic, by J. Brown, 731.

Vesta, Jupiter, and Uranus, spectrograms of, by P. Lowell, 555.

*Vibrations of a plucked string, Prof. W. B. Morton and T. B. Vinycomb on the, 511.

VICKERS (Miss Anna) *on the algæ of the Bay of Naples*, 262.

*Victoria, the new geological map of, J. Stirling on, 603.

VINES (Prof. S. H.) *on investigations made at the Marine Biological Laboratory, Plymouth*, 271.

*VINYCOMB (T. B.) and Prof. W. B. MORTON on the vibrations of a plucked string, 511.

Viscous fusion of rock-forming minerals, J. Joly on the, 602.

Volcanic rocks of Glencoe, the, and their relation to the granite of Ben Cruachan, H. Kynaston on, 602.

Voltaic potential differences, the relation of, to temperature, Dr. J. Larmor on, 546.

WAGER (Harold) *on the respiration of plants*, 472.

*—— the nucleus of the cyanophyceæ, 816.

*—— the function of the nucleolus, 818.

Wages, the regulation of, in developed industries, by Prof. S. J. Chapman, 708.

WALKER (A. O.) on the amphipods collected by Professor Herdman, 643.

WALKINGTON (Miss L. A.), some urgent needs of a great city, 709.

WALLIS (E. White) *on the conditions of health essential to the carrying on of the work of instruction in schools*, 483.

WARD (Prof. H. Marshall) *on the respiration of plants*, 472.

—— *on the cyanophyceæ*, 473.

WARD (J.) *on the Roman fort at Gellygaer*, 450.

Water, the variation of the critical velocity of, with temperature, further experiments by the thermal method on, by Dr. H. T. Barnes, 512.

*Water power in Ireland, by F. J. Dick, 733.

WATKIN (Col.) *on the B.A. screw gauge*, 350.

WATSON (A. T.) on the habits of the Onuphididæ (Polychæta), and on the internal structures with which they fortify their homes, 652.

WATTS (Dr. Marshall) *on wave-length tables of the spectra of the elements and compounds*, 137.

WATTS (Prof. W. W.) *on the movements of underground waters of North-west Yorkshire*, 224.

—— *on the collection of photographs of geological interest*, 229.

*—— Charnwood Forest, a buried triassic landscape, 687.

—— *on the work of the Corresponding Societies Committee*, 851.

—— Address to the Conference of Delegates at Belfast, 858.

Wave-length tables of the spectra of the elements and compounds, report on, 137.

WEBBER (Maj.-Gen.) *on the B.A. screw gauge*, 350.

Weisia rostellata, Lindb., in Ireland, by J. H. Davies, 819.

WEISS (Prof. F. E.) *on botanical photographs*, 471.

WELCH (R.) *on the collection of photographs of geological interest*, 229.

WELDON (Prof. W. F. R.) *on the occupation of a table at the Zoological Station at Naples*, 259.

—— *on investigations made at the Marine Biological Laboratory, Plymouth*, 271.

WELLBURN (E. D.), *a list of the fish fauna of the Pendleside limestones*, 222.

WHEELER (W. H.) *on terrestrial surface-waves and wave-like surfaces*, 285.

—— *on the resistance of road vehicles to traction*, 314.

WHIDBORNE (Rev. G. F.) *on the registration of type specimens of British fossils*, 210.
WHITAKER (W.) *on the work of the Corresponding Societies Committee*, 851.
WHITTAKER (E. T.) on the partial differential equations of mathematical physics, 523.
*WIGHAM (J. R.), a new flashing lighthouse light without intervals of darkness, 735.
WILLIS (J. C.) on the dorsiventrality of the podostemaceæ, with reference to current views of evolution, 806.
WILSON (Prof. Ernest), magnetic detectors in space telegraphy, 547.
—— the electrical conductivity of certain aluminium alloys as affected by exposure to London atmosphere, 734.
*WILSON (W.), two varieties of *Trifolium pratense perenne*, 819.
WILSON (Dr. W. E.), new solar radiation recorder, 521.
—— search for ultra-Neptunian planet, 521.
WIMPERIS (H. E.), a preliminary note on gas-engine explosions, 736.
WITHERS (Prof. H. L.) *on the conditions of health essential to the carrying on of the work of instruction in schools*, 483.
WOLFENDEN (Dr. R. Norris) *on the copepod sub-family* Ætidiinæ, *with a proposed revision of the classification*, 263.
Women's labour, the economic effect of legislation regulating, second report on, 286.
WOOD (G. H.) *on the economic effect of legislation regulating women's labour in the boot and shoe trades of Bristol and Kingswood*, 286.
WOOD (Sir H. T.) *on the B.A. screw gauge*, 350.
WOODCOCK (H. M.) *on the life-history of Sporozoa*, 27.
WOODS (H.) *on the registration of type specimens of British fossils*, 210.
WOODWARD (Dr. A. Smith) *on the registration of type specimens of British fossils*, 210.
—— on a carboniferous fish fauna from Victoria, Australia, 615.
WOODWARD (Dr. H.) *on the registration of type specimens of British fossils*, 210.
—— *on life-zones in the British carboniferous rocks*, 210.
—— *on the compilation of an index generum et specierum animalium*, 283.
*—— on the middle Cambrian trilobites, &c., of Mount Stephen, British Columbia, 598.
WOODWARD (H. B.) *on the collection of photographs of geological interest*, 229.
—— on the occurrence of Bagshot beds at Combe Pyne, near Lyme Regis, 601.
WOOLNOUGH (F.) *on the collection of photographs of geological interest*, 229.
WORSDELL (W. C.), the morphology of sporangial integuments, 812.
—— the nature of the vascular system of the stem in certain dicotyledonous orders, 814.
WRIGHT (Herbert), foliar periodicity in Ceylon, 807.
—— sex in the Ceylon species of *Diospyros*, 819.
WRIGHT (J.) on the marine fauna of the boulder clay, 598.
WYNNE (Dr. W. P.) *on isomorphous sulphonic derivatives of benzene*, 180.

**Xenopus (Dactylethra)*, the development of, by E. J. Bles, 657.

Yorkshire, North-west, third report on the movements of underground waters of, 224.
YOUNG (R. M.) on the excavation of a primitive site near Groomsport, co. Down, 759.
Yünnan, by Capt. C. H. D. Ryder, 678.

*ZOBEL (S.) and Dr. W. A. OSBORNE, the hydrolysis of glycogen, 780.
Zoological Station at Naples, report on the occupation of a table at the, 259.
Zoology, Address by Prof. G. B. Howes to the Section of, 618.
Zoology of the Sandwich Islands, twelfth report on the, 284.

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REPORT OF THE SEVENTY-FIRST MEETING, at Glasgow, September, 1901, *Published at* £1 4*s*.

CONTENTS.

PAGE
Rules of the Association, Lists of Officers, Report of the Council, List of Committees, Grants of Money, &c. . . . . xxix–cxx
Address by the President, Professor A. W. Rücker 3
Report on the Determination of the Components of Magnetic Force on Board Ship 29
Report on Electrical Standards 31
Note on the Variation of the Specific Heat of Water. By Professor H. L. CALLENDAR 34
Report on Radiation in a Magnetic Field 39
Interference and Polarisation of Electric Waves. By Professor Dr. G. QUINCKE 39
Sixth Report on Seismological Investigations 40
Report on the Calculation of Tables of certain Mathematical Functions . . 54
Report on Meteorological Observations on Ben Nevis 54
The Cleaning of Turbid Solutions, and the Movement of Small Suspended Particles by the Influence of Light. By Professor G. QUINCKE . . . 60
Twenty-second Report on Underground Temperature 64
Note sur l'Unité de Pression. Par le Dr. C. E. GUILLAUME 71
Report on the Nature of Alloys 75
Second Report on Isomorphous Derivatives of Benzene 78
Report on Wave-length Tables of the Spectra of the Elements and Compounds 79

PAGE
Report on Isomeric Naphthalene Derivatives 152
Report on the Bibliography of Spectroscopy 155
Third Report on the Relation between the Absorption Spectra and Chemical Constitution of Organic Substances 208
The Methods for the Determination of Hydrolytic Dissociation of Salt-Solutions. By Dr. R. C. FARMER 240
The Relative Progress of the Coal-tar Industry in England and Germany during the past Fifteen Years. By ARTHUR G. GREEN 252
The Application of the Equilibrium Law to the Separation of Crystals from Complex Solutions and to the Formation of Oceanic Salt Deposits. By Dr. E. FRANKLAND ARMSTRONG 262
Interim Report on the Exploration of Irish Caves 282
Report on the Erratic Blocks of the British Isles 283
Report on the Life-zones in the British Carboniferous Rocks 285
Report on the present State of our Knowledge of the Structure of Crystals . 297
Second Report on the Movements of Underground Waters of North-west Yorkshire 337
Twelfth Report on Photographs of Geological Interest in the United Kingdom 339
Report on the Ossiferous Caves at Uphill 352
Eleventh Report on the Zoology of the Sandwich Islands 352
Interim Report on the Plankton and Physical Conditions of the English Channel, 1899–1900 353
Report on the Occupation of a Table at the Zoological Station at Naples . . 354
Report on the Compilation of an Index Animalium 362
Second Report on the Coral Reefs of the Indian Regions 363
Fourth Interim Report on working out the Details of the Observations of the Migration of Birds at Lighthouses and Lightships, 1880–87 364
Report on Investigations made at the Marine Biological Laboratory, Plymouth 376
Some Notes on the Behaviour of Young Gulls artificially hatched. By Professor J. ARTHUR THOMSON 378
Report on Changes of the Land Level of the Phlegræan Fields 382
Tenth and Final Report on the Climatology of Africa 383
Report on the Survey of British Protectorates 396
First Report on Terrestrial Surface Waves 398
First Report on the Economic Effect of Legislation regulating Women's Labour 399
Report on the Resistance of Road Vehicles to Traction 402
Report on the Means by which Practical Effect can be given to the Introduction of the Screw-gauge proposed by the Association in 1884 407
Report on an Ethnological Survey of Canada 409
Second Report on the Natural History and Ethnography of the Malay Peninsula 411
Report on the Silchester Excavation 425
Report on the Age of Stone Circles 427
Report on Explorations in Crete 440
Report on the Micro-chemistry of Cells 445
Interim Report on the Chemistry of Bone Marrow 447
Report on the Morphology, Ecology, and Taxonomy of the Podostemaceæ . 447
Report on Fertilisation in the Phæophyceæ 448
The Influence of the Universities on School Education. By the BISHOP OF HEREFORD 448
Report on the Teaching of Science in Elementary Schools 458
Report of the Corresponding Societies Committee 465
Report of the Conference of Delegates of Corresponding Societies held at Glasgow 466
The Transactions of the Sections 519
Index 871
List of Publications 899

(Appendix, List of Members, &c., pp. 1–114.)

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L. L. Price, Esq., M.A.

LIST OF MEMBERS

OF THE

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

1902.

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* indicates Life Members entitled to the Annual Report.

§ indicates Annual Subscribers entitled to the Annual Report for 1902.

‡ indicates Subscribers not entitled to the Annual Report.

Names without any mark before them are Life Members, elected before 1845, not entitled to the Annual Report.

Names of Members of the GENERAL COMMITTEE are printed in SMALL CAPITALS.

Names of Members whose addresses are incomplete or not known are in *italics*.

Notice of changes of residence should be sent to the Assistant General Secretary, Burlington House, W.

Year of Election.

1887. *ABBE, Professor CLEVELAND. Weather Bureau, Department of Agriculture, Washington, U.S.A.
1897. ‡Abbott, A. H. Brockville, Ontario, Canada.
1898. §Abbott, George, M.R.C.S. 33 Upper Grosvenor-road, Tunbridge Wells.
1881. *Abbott, R. T. G. Whitley House, Malton.
1887. ‡Abbott, T. C. Eastleigh, Queen's-road, Bowdon, Cheshire.
1902. ‡ABERCORN, the Duke of, K.G. Barons Court, Ireland.
1885. *ABERDEEN, The Right Hon. the Earl of, G.C.M.G., LL.D. Haddo House, Aberdeen.
1885. ‡Aberdeen, The Countess of. Haddo House, Aberdeen.
1885. ‡Abernethy, James W. 2 Rubislaw-place, Aberdeen.
1873. *ABNEY, Captain Sir W. DE W., K.C.B., D.C.L., F.R.S., F.R.A.S. (Pres. A, 1889; Council, 1884–89, 1902–). Rathmore Lodge, Bolton-gardens South, Earl's Court, S.W.
1886. ‡Abraham, Harry. 147 High-street, Southampton.
1884. ‡Acheson, George. Collegiate Institute, Toronto, Canada.
1873. ‡Ackroyd, Samuel. Greaves-street, Little Horton, Bradford, Yorkshire.
1900. §Ackroyd, William. Borough Laboratory, Crossley-street, Halifax.

Year of Election.

1882. *Acland, Alfred Dyke. 38 Pont-street, Chelsea, S.W.
1869. ‡Acland, Sir C. T. Dyke, Bart., M.A. Killerton, Exeter.
1877. *Acland, Captain Francis E. Dyke, R.A. Woodmansterne Rectory, Banstead, Surrey.
1873. *Acland, Rev. H. D., M.A. Lamorva, Falmouth.
1894. *Acland, Henry Dyke, F.G.S. The Old Bank, Great Malvern.
1877. *Acland, Theodore Dyke, M.D. 19 Bryanston-square, W.
1898. ‡Acworth, W. M. 47 St. George's-square, S.W.
1901. §Adam, J. M. 15 Walmer-crescent, Glasgow.
1887. ‡ADAMI, J. G., M.A., M.D., Professor of Pathology in the University, Montreal, Canada.
1892. ‡Adams, David. Rockville, North Queensferry.
1884. ‡Adams, Frank Donovan. Geological Survey, Ottawa, Canada.
1901. §Adams, John, M.A. 12 Holyrood-crescent, Glasgow.
1871. ‡Adams, John R. 2 Nutley-terrace, Hampstead, N.W.
1869. *ADAMS, WILLIAM GRYLLS, M.A., D.Sc., F.R.S., F.G.S., F.C.P.S. (Pres. A, 1880; Council 1878–85), Professor of Natural Philosophy and Astronomy in King's College, London. 43 Campden Hill-square, W.
1901. §Adamson, P. 11 Fairlie Park-drive, Glasgow.
1896. ‡Adamson, W. Sunnyside House, Prince's Park, Liverpool.
1898. §Addison, William L. T. Byng Inlet, Ontario, Canada.
1890. ‡Addyman, James Wilson, B.A. Belmont, Starbeck, Harrogate.
1890. ‡ADENEY, W. E., B.Sc., F.C.S. Royal University of Ireland, Earlsfort-terrace, Dublin.
1899. §Adie, R. H., M.A., B.Sc. 136 Huntingdon-road, Cambridge.
1883. ‡Adshead, Samuel. School of Science, Macclesfield.
1884. ‡Agnew, Cornelius R. 266 Maddison-avenue, New York, U.S.A.
1902. §Agnew, Samuel, M.D. Bengal-place, Dublin.
1864. *Ainsworth, David. The Flosh, Cleator, Carnforth.
1871. *Ainsworth, John Stirling. Harecroft, Gosforth, Cumberland.
1871. ‡Ainsworth, William M. The Flosh, Cleator, Carnforth.
1895. *Airy, Hubert, M.D. Stoke House, Woodbridge, Suffolk.
1891. *Aisbitt, M. W. Mountstuart-square, Cardiff.
1871. §AITKEN, JOHN, LL.D., F.R.S., F.R.S.E. Ardenlea, Falkirk, N.B.
1901. §Aitken, Thomas. County Buildings, Cupar, Fife.
1898. ‡AKERS-DOUGLAS, Right Hon. A., M.P. 106 Mount-street, W.
1884. *Alabaster, H. Milton, Grange-road, Sutton, Surrey.
1886. *Albright, G. S. The Elms, Edgbaston, Birmingham.
1900. §Aldren, Francis J., M.A. The Lizans, Malvern Link.
1896. §Aldridge, J. G. W., Assoc.M.Inst.C.E. 9 Victoria-street, Westminster, S.W.
1894. ‡Alexander, A. W. Blackwall Lodge, Halifax.
1891. ‡Alexander, D. T. Dynas Powis, Cardiff.
1883. ‡Alexander, George. Kildare-street Club, Dublin.
1888. *Alexander, Patrick Y. The Mount, Batheaston, Somerset.
1896. ‡Alexander, William. 45 Highfield South, Rockferry, Cheshire.
1891. *Alford, Charles J., F.G.S. 15 Great St. Helens, E.C.
1883. ‡Alger, Miss Ethel. The Manor House, Stoke Damerel, South Devon.
1883. ‡Alger, W. H. The Manor House, Stoke Damerel, South Devon.
1883. ‡Alger, Mrs. W. H. The Manor House, Stoke Damerel, South Devon.
1867. ‡Alison, George L. C. Dundee.
1885. ‡Allan, David. West Cults, near Aberdeen.
1871. ‡Allan, G., M.Inst.C.E. 10 Austin Friars, E.C.
1901. *Allan, James A. Westerton, Milngavie.

Year of Election.

1871. ‡ALLEN, ALFRED H., F.C.S. 67 Surrey-street, Sheffield.
1879. *Allen, Rev. A. J. C. 13 Downing-grove, Cambridge.
1898. §ALLEN, E. J. The Laboratory, Citadel Hill, Plymouth.
1888. ‡ALLEN, F. J., M.A., M.D., Professor of Physiology. The University, Birmingham.
1884. ‡Allen, Rev. George. Shaw Vicarage, Oldham.
1891. ‡Allen, Henry A., F.G.S. Geological Museum, Jermyn-street, S.W.
1887. ‡Allen, John. 14 Park-road, St. Anne's-on-the-Sea, viâ Preston.
1878. ‡Allen, John Romilly. 28 Great Ormond-street, W.C.
1889. ‡Allhusen, Alfred. Low Fell, Gateshead.
1896. ‡Alsop, J. W. 16 Bidston-road, Oxton.
1882. *Alverstone, The Right Hon. Lord, G.C.M.G., LL.D., F.R.S. Hornton Lodge, Hornton-street, Kensington, S.W.
1887. ‡Alward, G. L. 11 Hamilton-street, Grimsby, Yorkshire.
1873. ‡Ambler, John. North Park-road, Bradford, Yorkshire.
1891. ‡Ambrose, D. R. Care of Messrs. J. Evans & Co., Bute Docks, Cardiff.
1883. §Amery, John Sparke. Druid, Ashburton, Devon.
1883. §Amery, Peter Fabyan Sparke. Druid, Ashburton, Devon.
1884. ‡AMI, HENRY, M.A., D.Sc., F.G.S. Geological Survey, Ottawa, Canada.
1883. ‡Anderson, Miss Constance. 17 Stonegate, York.
1885. *ANDERSON, HUGH KERR. Caius College, Cambridge.
1901. *Anderson, James. 1 Marlborough-terrace, Glasgow.
1874. ‡Anderson, John, J.P., F.G.S. Holywood, Belfast.
1892. ‡Anderson, Joseph, LL.D. 8 Great King-street, Edinburgh.
1899. *Anderson, Miss Mary K. 13 Napier-road, Edinburgh.
1888. *Anderson, R. Bruce. 35A Great George-street, S.W.
1887. ‡Anderson, Professor R. J., M.D., F.L.S. Queen's College, and Atlantic Lodge, Salthill, Galway.
1889. ‡Anderson, R. Simpson. Elswick Collieries, Newcastle-upon-Tyne.
1880. *ANDERSON, TEMPEST, M.D., B.Sc., F.G.S. (Local Sec. 1881). 17 Stonegate, York.
1902. *Anderson, Thomas. 41 Cliftonville-road, Belfast.
1901. *Anderson, Dr. W. Carrick. 2 Florentine-gardens, Glasgow
1901. ‡Anderson, W. F. G. 47 Union-street, Glasgow.
1883. ‡Andrew, Thomas, F.G.S. 18 Southernhay, Exeter.
1895. ‡Andrews, Charles W. British Museum (Natural History), S.W.
1891. ‡Andrews, Thomas. 163 Newport-road, Cardiff.
1880. *Andrews, Thornton, M.Inst.C.E. Cefn Eithen, Swansea.
1886. §Andrews, William, F.G.S. Steeple Croft, Coventry.
1883. ‡Anelay, Miss M. Mabel. Girton College, Cambridge.
1877. §ANGELL, JOHN, F.C.S., F.I.C. 6 Beacons-field, Derby-road, Withington, Manchester.
1886. ‡Annan, John, J.P. Whitmore Reans, Wolverhampton.
1900. ‡Annandale, Nelson. 23 Salisbury-road, Cressington Park, Liverpool.
1896. ‡Annett, R. C. F. 4 Buckingham-avenue, Sefton Park, Liverpool.
1886. ‡Ansell, Joseph. 38 Waterloo-street, Birmingham.
1878. ‡Anson, Frederick H. 15 Dean's-yard, Westminster, S.W.
1890. §Antrobus, J. Coutts. Eaton Hall, Congleton.
1901. ‡Arakawa, Minozi. Japanese Consulate, 84 Bishopsgate-street Within, E.C.
1900. §Arber, E. A. N., B.A. Trinity College, Cambridge.
1898. ‡*Archer, G. W.* 11 *All Saints'-road, Clifton, Bristol.*
1894. §Archibald, A. The Bank House, Ventnor.
1884. *Archibald, E. Douglas. 32 Shaftesbury-avenue, W.
1883. §Armistead, Richard. Chambres House, Southport.

Year of Election.

1883. *Armistead, William. Hillcrest, Oaken, Wolverhampton.
1873. *ARMSTRONG, HENRY E., Ph.D., LL.D., F.R.S. (Pres. B, 1885; Pres. L, 1902; Council 1899–), Professor of Chemistry in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 55 Granville-park, Lewisham, S.E.
1889. ‡Armstrong, Thomas John. 14 Hawthorn-terrace, Newcastle-upon-Tyne.
1893. ‡Arnold-Bemrose, H., M.A., F.G.S. 56 Friar-gate, Derby.
1901. ‡Arthur, Matthew. 78 Queen-street, Glasgow.
1870. *Ash, Dr. T. Linnington. Penroses, Holsworthy, North Devon.
1874. ‡Ashe, Isaac, M.B. Dundrum, Co. Dublin.
1889. ‡Ashley, Howard M. Airedale, Ferrybridge, Yorkshire.
1887. ‡Ashton, Thomas Gair, M.A. 36 Charlotte-street, Manchester.
**Ashworth, Edmund. Egerton Hall, Bolton-le-Moors.*
Ashworth, Henry. Turton, near Bolton.
1888. *Ashworth, J. Jackson. Haslen House, Handforth, Cheshire.
1890. ‡Ashworth, J. Reginald, B.Sc. 105 Freehold-street, Rochdale.
1887. ‡Ashworth, John Wallwork, F.G.S. Thorne Bank, Heaton Moor, Stockport.
1887. ‡Ashworth, Mrs. J. W. Thorne Bank, Heaton Moor, Stockport.
1875. *Aspland, W. Gaskell. Tuplins, Newton Abbot.
1861. ‡*Asquith, J. R. Infirmary-street, Leeds.*
1896. *Assheton, Richard. Grantchester, Cambridge.
1896. §Atkin, George, J.P. Egerton Park, Rockferry.
1887. §Atkinson, Rev. C. Chetwynd, D.D. Ingestre, Ashton-on-Mersey.
1884. ‡Atkinson, Edward, Ph.D., LL.D. Brookline, Massachusetts, U.S.A.
1898. *Atkinson, E. Cuthbert. St. John's College, Oxford.
1894. ‡Atkinson, George M. 28 St. Oswald's-road, S.W.
1894. *Atkinson, Harold W. Boys' High School, Pretoria, South Africa.
1881. ‡Atkinson, J. T. The Quay, Selby, Yorkshire.
1881. ‡ATKINSON, ROBERT WILLIAM, F.C.S. (Local Sec. 1891). 44 Loudoun-square, Cardiff.
1894. §Atkinson, William. Erwood, Beckenham, Kent.
1863. *ATTFIELD, J., M.A., Ph.D., F.R.S., F.C.S. Watford, Herts.
1884. ‡Auchincloss, W. S. Atlantic Highlands, New Jersey, U.S.A.
1853. *AVEBURY, The Right Hon. Lord, D.C.L., F.R.S. (PRESIDENT, 1881; TRUSTEE, 1872– ; Pres. D, 1872; Council 1865–71). High Elms, Farnborough, Kent.
1901. §Aveling, T. C. 32 Bristol-street, Birmingham.
1877. *AYRTON, W. E., F.R.S. (Pres. A, 1898; Council 1889–96), Professor of Electrical Engineering in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 41 Kensington Park-gardens, W.

1884. ‡Baby, The Hon. G. Montreal, Canada.
1900. ‡BACCHUS, RAMSDEN (Local Sec. 1900). 15 Welbury-drive, Bradford.
1883. *Bach, Madame Henri. 12 Rue Fénélon, Lyons.
Backhouse, Edmund. Darlington.
1863. ‡Backhouse, T. W. West Hendon House, Sunderland.
1883. *Backhouse, W. A. St. John's, Wolsingham, R.S.O., Durham.
1887. *Bacon, Thomas Walter. Ramsden Hall, Billericay, Essex.
1887. ‡Baddeley, John. 1 Charlotte-street, Manchester.
1883. ‡Baildon, Dr. 42 Hoghton-street, Southport.
1892. ‡Baildon, H. Bellyse. Duncliffe, Murrayfield, Edinburgh.
1883. *Bailey, Charles, F.L.S. Atherstone House, North-drive, St. Anne's-on-the-Sea, Lancashire.

Year of Election.

1893. §BAILEY, Colonel F., Sec. R.Scot.G.S., F.R.G.S. 7 Drummond-place, Edinburgh.
1870. ‡Bailey, Dr. Francis J. 51 Grove-street, Liverpool.
1887. *Bailey, G. H., D.Sc., Ph.D. Marple Cottage, Marple, Cheshire.
1899. ‡Bailey, T. Lewis. Fernhill, Formby, Lancashire.
1855. ‡Bailey, W. Horseley Fields Chemical Works, Wolverhampton.
1894. *Baily, Francis Gibson, M.A. 11 Ramsay-garden, Edinburgh.
1878. ‡BAILY, WALTER. 4 Roslyn-hill, Hampstead, N.W.
1885. ‡BAIN, ALEXANDER, M.A., LL.D. Ferryhill Lodge, Aberdeen.
1897. §BAIN, JAMES, jun. Toronto.
1885. ‡Bain, William N. Collingwood, Pollokshields, Glasgow.
1882. *BAKER, Sir BENJAMIN, K.C.B., K.C.M.G., LL.D., D.Sc., F.R.S., M.Inst.C.E. (Pres. G, 1885; Council, 1889–96). 2 Queen Square-place, Westminster, S.W.
1886. §Baker, Harry, F.I.C. Epworth House, Moughland-lane, Runcorn.
1898. ‡Baker, Herbert M. Wallcroft, Durdham Park, Clifton, Bristol.
1898. ‡Baker, Hiatt C. Mary-le-Port-street, Bristol.
1891. ‡Baker, J. W. 50 Stacey-road, Cardiff.
1881. ‡Baker, Robert, M.D. The Retreat, York.
1875. ‡BAKER, W. PROCTOR. Bristol.
1881. ‡Baldwin, Rev. G. W. de Courcy, M.A. Warshill Vicarage, York.
1884. ‡Balete, Professor E. Polytechnic School, Montreal, Canada.
1871. ‡Balfour, The Right Hon. G. W., M.P. 24 Addison-road, Kensington, W.
1894. §BALFOUR, HENRY, M.A. 11 Norham-gardens, Oxford.
1875. ‡BALFOUR, ISAAC BAYLEY, M.A., D.Sc., M.D., F.R.S., F.R.S.E., F.L.S., (Pres. D, 1894; K, 1901), Professor of Botany in the University of Edinburgh. Inverleith House, Edinburgh.
1883. ‡Balfour, Mrs. I. Bayley. Inverleith House, Edinburgh.
1878. *Ball, Charles Bent, M.D., Regius Professor of Surgery in the University of Dublin. 24 Merrion-square, Dublin.
1866. *BALL, Sir ROBERT STAWELL, LL.D., F.R.S., F.R.A.S. (Pres. A, 1887; Council 1884–90, 1892–94; Local Sec. 1878), Lowndean Professor of Astronomy and Geometry in the University of Cambridge. The Observatory, Cambridge.
1883. *Ball, W. W. Rouse, M.A. Trinity College, Cambridge.
1886. ‡Ballantyne, J. W., M.B. 24 Melville-street, Edinburgh.
1869. ‡Bamber, Henry K., F.C.S. 5 Westminster-chambers, Victoria-street, Westminster, S.W.
1890. ‡Bamford, Professor Harry, B.Sc. 3 Albany-street, Glasgow.
1899. §Bampton, Mrs. 42 Marine-parade, Dover.
1882. ‡Bance, Colonel Edward, J.P. Oak Mount, Highfield, Southampton.
1898. ‡Bannerman, W. Bruce, F.R.G.S., F.G.S. The Lindens, Sydenham-road, Croydon.
1884. ‡Barbeau, E. J. Montreal, Canada.
1866. ‡Barber, John. Long-row, Nottingham.
1890. *Barber-Starkey, W. J. S. Aldenham Park, Bridgnorth, Salop.
1861. *Barbour, George. Bolesworth Castle, Tattenhall, Chester.
1871. ‡Barclay, George. 17 Coates-crescent, Edinburgh.
1860. *Barclay, Robert. High Leigh, Hoddesden, Herts.
1887. *Barclay, Robert. Sedgley New Hall, Prestwich, Manchester.
1886. ‡Barclay, Thomas. 17 Bull-street, Birmingham.
1902. §Barcroft, H., D.L. The Glen, Newry, Co. Down.
1902. §Barcroft, Joseph. King's College, Cambridge.
1881. ‡Barfoot, William, J.P. Whelford-place, Leicester.
1882. ‡Barford, J. D. Above Bar, Southampton.
1886. ‡Barham, F. F. Bank of England, Birmingham.

Year of Election.

1890. ‡Barker, Alfred, M.A., B.Sc. Aske's Hatcham School, New Cross, S.E.

1899 §Barker, John H. Ashley-road, Loughborough.

1882. *Barker, Miss J. M. 18 Claremont-place, Newcastle-on-Tyne.

1879. *Barker, Rev. Philip C., M.A., LL.B. Priddy Vicarage, Wells, Somerset.

1898. §Barker, W. R. 106 Redland-road, Bristol.

1886. ‡Barling, Gilbert. 85 Edmund-street, Edgbaston, Birmingham.

1873. ‡Barlow, Crawford, B.A., M.Inst.C.E. Deene, Tooting Bec-road, Streatham, S.W.

1889. §Barlow, H. W. L., M.A., M.B., F.C.S. The Park Hospital, Hither Green, S.E.

1883. ‡Barlow, J. J. 48 Part-street, Southport.

1878. ‡Barlow, John, M.D., Professor of Physiology in St. Mungo's College, Glasgow.

1883. ‡Barlow, John R. Greenthorne, near Bolton.

1885. *BARLOW, WILLIAM, F.G.S. The Red House, Great Stanmore.

1902. §Barnard, J. E. Jenner Institute of Preventive Medicine, Chelsea-gardens, S.W.

1861. *Barnard, Major R. Cary, F.L.S. Bartlow, Leckhampton, Cheltenham.

1881. ‡Barnard, William, LL.B. 3 New-court, Lincoln's Inn, W.C.

1889. ‡Barnes, J. W. Bank, Durham.

1868. §Barnes, Richard H. Heatherlands House, Parkstone, Dorset.

1899. ‡Barnes, Robert. 9 Kildare-gardens, Bayswater, W.

1884. ‡Barnett, J. D. Port Hope, Ontario, Canada.

1901. ‡Barnett, P. A. Pietermaritzburg, South Africa.

1899. ‡Barnett, W. D. 41 Threadneedle-street, E.C.

1881. ‡BARR, ARCHIBALD, D.Sc., M.Inst.C.E. The University, Glasgow.

1890. ‡Barr, Frederick H. 4 South-parade, Leeds.

1859. ‡Barr, Lieut.-General. Apsleytoun, East Grinstead, Sussex.

1902. *Barr, Mark. 25 Kensington Court-gardens, W.

1891. ‡Barrell, Frank R., M.A., Professor of Mathematics in University College, Bristol.

1883. ‡Barrett, Mrs. J. C. Errismore, Birkdale, Southport.

1872. *BARRETT, W. F., F.R.S., F.R.S.E., M.R.I.A., Professor of Physics in the Royal College of Science, Dublin.

1883. ‡Barrett, William Scott. Abbotsgate, Huyton, near Liverpool.

1899. ‡BARRETT-HAMILTON, Capt. G. E. H. Kilmarnock, Arthurstown, Waterford, Ireland.

1887. ‡Barrington, Miss Amy. Fassaroe, Bray, Co. Wicklow.

1874. *BARRINGTON, R. M., M.A., LL.B., F.L.S. Fassaroe, Bray, Co. Wicklow.

1874. *Barrington-Ward, Mark J., M.A., F.L.S., F.R.G.S., H.M. Inspector of Schools. Thorneloe Lodge, Worcester.

1885. *Barron, Frederick Cadogan, M.Inst.C.E. Nervion, Beckenham-grove, Shortlands, Kent.

1866. ‡Barron, William. Elvaston Nurseries, Borrowash, Derby.

1893. *BARROW, GEORGE, F.G.S. Geological Survey Office, 28 Jermyn-street, S.W.

1886. ‡Barrow, George William. Baldraud, Lancaster.

1886. ‡Barrow, Richard Bradbury. Lawn House, 13 Ampton-road, Edgbaston, Birmingham.

1896. §Barrowman, James. Staneacre, Hamilton, N.B.

1886. ‡Barrows, Joseph. The Poplars, Yardley, near Birmingham.

1886. ‡Barrows, Joseph, jun. Ferndale, Harborne-road, Edgbaston, Birmingham.

1858. ‡BARRY, Right Rev. ALFRED, D.D., D.C.L. The Cloisters, Windsor.

Year of Election.

1883. ‡Barry, Charles E. 1 Victoria-street, S.W.
1881. ‡Barry, J. W. Duncombe-place, York.
1884. *Barstow, Miss Frances A. Garrow Hill, near York.
1890. *Barstow, J. J. Jackson. The Lodge, Weston-super-Mare.
1890. *Barstow, Mrs. The Lodge, Weston-super-Mare.
1892. ‡Bartholomew, John George, F.R.S.E., F.R.G.S. 12 Blacket-place, Edinburgh.
1858. *Bartholomew, William Hamond, M.Inst.C.E. Ridgeway House, Cumberland-road, Hyde Park, Leeds.
1884. ‡Bartlett, James Herbert. 148 Mansfield-street, Montreal, Canada.
1873. ‡Bartley, Sir G. C. T., K.C.B., M.P. St. Margaret's House, Victoria-street, S.W.
1892. ‡Barton, Miss. 4 Glenorchy-terrace, Mayfield, Edinburgh.
1893. ‡Barton, Edwin H., B.Sc. University College, Nottingham.
1884. ‡Barton, H. M. Foster-place, Dublin.
1852. ‡Barton, James, B.A., M.Inst.C.E. Farndreg, Dundalk.
1899. *Barton, Miss Ethel S. 7 Brechin-place, South Kensington, S.W.
1892. ‡Barton, William. 4 Glenorchy-terrace, Mayfield, Edinburgh.
1887. ‡Bartrum, John S. 13 Gay-street, Bath.
*Bashforth, Rev. Francis, B.D. Minting Vicarage, near Horncastle.
1898. ‡Bason, Vernon Millward. 7 Princess-buildings, Clifton, Bristol.
1876. ‡Bassano, Alexander. 12 Montagu-place, W.
1888. *BASSET, A. B., M.A., F.R.S. Fledborough Hall, Holyport, Berkshire.
1891. ‡Bassett, A. B. Cheverell, Llandaff.
1866. *BASSETT, HENRY. 26 Belitha-villas, Barnsbury, N.
1889. ‡BASTABLE, Professor C. F., M.A., F.S.S. (Pres. F, 1894). 6 Trevelyan-terrace, Rathgar, Co. Dublin.
1869. ‡Bastard, S. S. Summerland-place, Exeter.
1871. ‡BASTIAN, H. CHARLTON, M.A., M.D., F.R.S., F.L.S., Emeritus Professor of the Principles and Practice of Medicine in University College, London. 8A Manchester-square, W.
1889. ‡Batalha-Reis, J. Portuguese Consulate, Newcastle-upon-Tyne.
1883. ‡BATEMAN, Sir A. E., K.C.M.G., Controller-General Statistical Department. Board of Trade, 7 Whitehall Gardens, S.W.
1868. ‡Bateman, Sir F., M.D., LL.D. Upper St. Giles's-street, Norwich.
1889. ‡Bates, C. J. Heddon, Wylam, Northumberland.
1884. ‡BATESON, WILLIAM, M.A., F.R.S. St. John's College, Cambridge.
1881. *BATHER, FRANCIS ARTHUR, M.A., D.Sc., F.G.S. British Museum (Natural History), S.W.
1863. §BAUERMAN, H., F.G.S. 14 Cavendish-road, Balham, S.W.
1867. ‡Baxter, Edward. Hazel Hall, Dundee.
1892. ‡Bayly, F. W. 8 Royal Mint, E.
1875. *Bayly, Robert. Torr Grove, near Plymouth.
1876. *BAYNES, ROBERT E., M.A. Christ Church, Oxford.
1887. *Baynes, Mrs. R. E. 2 Norham-gardens, Oxford.
1883. *Bazley, Gardner S. Hatherop Castle, Fairford, Gloucestershire.
Bazley, Sir Thomas Sebastian, Bart., M.A. Winterdyne, Chine Crescent-road, Bournemouth.
1886. ‡Beale, C. Calle Progress No. 83, Rosario de Santa Fé, Argentine Republic.
1886. ‡Beale, Charles G. Maple Bank, Edgbaston, Birmingham.
1860. *BEALE, LIONEL S., M.B., F.R.S. 61 Grosvenor-street, W.
1884. ‡Beamish, G. H. M. Prison, Liverpool.
1872. ‡Beanes, Edward, F.C.S. Moatlands, Paddock Wood, Brenchley, Kent.
1883. ‡Beard, Mrs. Oxford.
1889. §BEARE, Prof. T. HUDSON, B.Sc., F.R.S.E., M.Inst.C.E. The University, Edinburgh.

Year of Election.

1842. *Beatson, William. 2 Ash-mount, Rotherham.

1889. ‡Beattie, John. 5 Summerhill-grove, Newcastle-upon-Tyne.

1902. §Beatty, H. M., LL.D. Ballymena, Co. Antrim.

1855. *Beaufort, W. Morris, F.R.A.S., F.R.G.S., F.R.M.S., F.S.S. 18 Piccadilly, W.

1886. ‡Beaugrand, M. H. Montreal.

1900. ‡Beaumont, Prof. Roberts, M.I.Mech.E. Yorkshire College, Leeds.

1861. *Beaumont, Rev. Thomas George. Oakley Lodge, Leamington.

1887. *Beaumont, W. J. The Laboratory, Citadel Hill, Plymouth.

1885. *BEAUMONT, W. W., M.Inst.C.E. Outer Temple, 222 Strand, W.C.

1896. ‡Beazer, C. Hindley, near Wigan.

1887. *BECKETT, JOHN HAMPDEN. Corbar Hall, Buxton, Derbyshire.

1885. ‡BEDDARD, FRANK E., M.A., F.R.S., F.Z.S., Prosector to the Zoological Society of London, Regent's Park, N.W.

1870. §BEDDOE, JOHN, M.D., F.R.S. (Council, 1870–75). The Chantry, Bradford-on-Avon.

1858. §Bedford, James. Woodhouse Cliff, near Leeds.

1890. ‡Bedford, James E., F.G.S. Shireoak-road, Leeds.

1891. §Bedlington, Richard. Gadlys House, Aberdare.

1878. ‡BEDSON, P. PHILLIPS, D.Sc., F.C.S. (Local Sec. 1889), Professor of Chemistry in the College of Physical Science, Newcastle-upon-Tyne.

1884. ‡Beers, W. G., M.D. 34 Beaver Hall-terrace, Montreal, Canada.

1873. ‡Behrens, Jacob. Springfield House, North-parade, Bradford, Yorkshire.

1901. *Beilby, George T. 11 University-gardens, Glasgow.

1874. ‡Belcher, Richard Boswell. Blockley, Worcestershire.

1891. *Belinfante, L. L., M.Sc., Assist.-Sec. G.S. Burlington House, W.

1892. ‡Bell, A. Beatson. 17 Lansdowne-crescent, Edinburgh.

1871. ‡Bell, Charles B. 6 Spring-bank, Hull.

1884. ‡Bell, Charles Napier. Winnipeg, Canada.

1894. ‡BELL, F. JEFFREY, M.A., F.Z.S. 35 Cambridge-street, Hyde Park, W.

Bell, Frederick John. Woodlands, near Maldon, Essex.

1860. ‡BELL, Rev. GEORGE CHARLES, M.A. Marlborough College, Wilts.

1900. *Bell, H. Wilkinson. Holmehurst, Rawdon, near Leeds.

1862. *BELL, Sir ISAAC LOWTHIAN, Bart., LL.D., F.R.S., F.C.S., M.Inst.C.E. (Pres. B, 1889). Rounton Grange, Northallerton.

1875. ‡BELL, JAMES, C.B., D.Sc., Ph.D., F.R.S. 52 Cromwell-road, Hove, Brighton.

1896. ‡Bell, James. Care of the Liverpool Steam Tug Co., Limited, Chapel-chambers, 28 Chapel-street, Liverpool.

1871. *BELL, J. CARTER, F.C.S. Bankfield, The Cliff, Higher Broughton, Manchester.

1883. *Bell, John Henry. 100 Leyland-road, Southport.

1864. ‡Bell, R. Queen's College, Kingston, Canada.

1888. *Bell, Walter George, M.A. Trinity Hall, Cambridge.

1893. ‡BELPER, The Right Hon. Lord, LL.M. Kingston, Nottinghamshire.

1884. ‡Bemrose, Joseph. 15 Plateau-street, Montreal, Canada.

1885. ‡BENHAM, WILLIAM BLAXLAND, D.Sc., Professor of Biology in the University of Otago, New Zealand.

1891. ‡*Bennett, Alfred Rosling. 44 Manor Park-road, Harlesden, N.W.*

1896. ‡Bennett, George W. West Ridge, Oxton, Cheshire.

1881. ‡Bennett, John Ryan. 3 Upper Belgrave-road, Clifton, Bristol.

1883. *Bennett, Laurence Henry. The Elms, Paignton, South Devon.

1901. §Bennett, Peter. 6 Kelvinhaugh-street, Sandyford, Glasgow.

Year of Election.

1896. ‡Bennett, Richard. 19 Brunswick-street, Liverpool.
1881. ‡Bennett, Rev. S. H., M.A. St. Mary's Vicarage, Bishopshill Junior, York.
1889. ‡Benson, John G. 12 Grey-street, Newcastle-upon Tyne.
1901. *Benson, Miss Margaret J., D.Sc. Royal Holloway College, Egham.
1887. *Benson, Mrs. W. J Care of W. J. Benson, Esq., Standard Bank, Johannesburg, Transvaal.
1863. ‡Benson, William. Fourstones Court, Newcastle-upon-Tyne.
1898. *Bent, Mrs. Theodore. 13 Great Cumberland-place, W.
1884. ‡Bentham, William. 724 Sherbrooke-street, Montreal, Canada.
1897. ‡Bently, R. R. 97 Dowling-avenue, Toronto, Canada.
1896. *Bergin, William, M.A., Professor of Natural Philosophy in Queen's College, Cork.
1901. ‡Bergins, Walter L. 8 Marlborough-terrace, Glasgow.
1894. §Berkeley, The Right Hon. the Earl of, F.G.S. Foxcombe, Boarshill, near Abingdon.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1886. ‡Bernard, W. Leigh. Calgary, Canada.
1898. §Berridge, Miss C. E. Dunton Lodge, The Knowle, Beckenham, Kent.
1894. §Berridge, Douglas, M.A., F.C.S. The College, Malvern.
1862. ‡**Besant, William Henry**, M.A., D.Sc., F.R.S. St. John's College, Cambridge.
1882. *Bessemer, Henry. Moorlands, Bitterne, Southampton.
1890. ‡Best, William Woodham. 31 Lyddon-terrace, Leeds.
1880. ***Bevan, Rev. James Oliver**, M.A., F.S.A., F.G.S. Chillenden Rectory, Dover.
1885. ‡Beveridge, R. Beath Villa, Ferryhill, Aberdeen.
1884. *Beverley, Michael, M.D. 54 Prince of Wales-road, Norwich.
1870. ‡*Bickerton, A. W. Newland-terrace, Queen's-road, Battersea, S.W.*
1888. *Bidder, George Parker. Savile Club, Piccadilly, W.
1885. ***Bidwell, Shelford**, Sc.D., LL.B., F.R.S. Riverstone Lodge, Southfields, Wandsworth, Surrey, S.W.
1882. §Biggs, C. H. W., F.C.S. Glebe Lodge, Champion Hill, S.E.
1898. §Billington, Charles. Studleigh, Longport, Staffordshire.
1901. *Bilsland, William, J.P. 28 Park-circus, Glasgow.
1886. ‡Bindloss, G. F. Carnforth, Brondesbury Park, N.W.
1887. *Bindloss, James B. Elm Bank, Eccles, Manchester.
1884. *Bingham, Lieut.-Colonel John E., J.P. West Lea, Ranmoor, Sheffield.
1881. ‡**Binnie, Sir Alexander R.**, M.Inst.C.E., F.G.S. (Pres. G, 1900). 77 Ladbroke-grove, W.
1873. ‡Binns, J. Arthur. 31 Manor-row, Manningham, Bradford, Yorkshire.
1900. ‡Bird, F. J. Norton House, Midsomer Norton, Bath.
1880. ‡Bird, Henry, F.C.S. South Down House, Millbrook, near Devonport.
1888. *Birley, Miss Caroline. 14 Brunswick-gardens, Kensington, W.
1887. *Birley, H. K. Hospital, Chorley, Lancashire.
1894. ‡Bisset, James, F.R.S.E. 9 Greenhill-park, Edinburgh.
1885. ‡Bissett, J. P. Wyndem, Banchory, N.B.
1886. *Bixby, Major W. H. Engineer's Office, Jones Building, Detroit, Michigan, U.S.A.
1901. ‡Black, John Albert. Lagarie-row, Helensburgh, N.B.
1889. ‡Black, W. 1 Lovaine-place, Newcastle-upon-Tyne.
1881. ‡Black, Surgeon-Major William Galt, F.R.C.S.E. Caledonian United Service Club, Edinburgh.

Year of Election.

1901. §Black, W. P. M. 136 Wellington-street, Glasgow.
1876. ‡Blackburn, Hugh, M.A. Roshven, Fort William, N.B.
1884. ‡Blackburn, Robert. New Edinburgh, Ontario, Canada.
1900. ‡Blackburn, W. Owen. 3 Mount Royd, Bradford.
1877. ‡Blackie, J. Alexander. 17 Stanhope-street, Glasgow.
1855. *BLACKIE, W. G., Ph.D., F.R.G.S. (Local Sec. 1876). 1 Belhaven-terrace, Kelvinside, Glasgow.
1884. ‡Blacklock, Frederick W. 25 St. Famille-street, Montreal, Canada.
1896. ‡*Blackwood, J. M. 16 Oil-street, Liverpool.*
1886. ‡Blaikie, John, F.L.S. The Bridge House, Newcastle, Staffordshire.
1895. ‡Blaikie, W. B. 6 Belgrave-crescent, Edinburgh.
1883. ‡Blair, Mrs. Oakshaw, Paisley.
1892. ‡Blair, Alexander. 35 Moray-place, Edinburgh.
1892. ‡Blair, John. 9 Ettrick-road, Edinburgh.
1883. *BLAKE, Rev. J. F., M.A., F.G.S. 35 Harlesden-gardens, N.W.
1902. §Blake, Robert F., F.I.C. 66 Malone-avenue, Belfast.
1891. ‡BLAKESLEY, THOMAS H., M.A., M.Inst.C.E. Royal Naval College, Greenwich, S.E.
1894. ‡Blakiston, Rev. C. D. Exwick Vicarage, Exeter.
1900. *Blamires, Joseph. Bradley Lodge, Huddersfield.
1881. ‡Blamires, Thomas H. Close Hill, Lockwood, near Huddersfield.
1895. ‡Blamires, William. Oak House, Taylor Hill, Huddersfield.
1884. *Blandy, William Charles, M.A. 1 Friar-street, Reading.
1869. ‡BLANFORD, W. T., LL.D., F.R.S., F.G.S., F.R.G.S. (Pres. C, 1884; Council 1885-91). 72 Bedford-gardens, Campden Hill, W.
1887. *Bles, A. J. S. Palm House, Park-lane, Higher Broughton, Manchester.
1887. *Bles, Edward J., B.Sc. The University, Glasgow.
1887. ‡Bles, Marcus S. The Beeches, Broughton Park, Manchester.
1884. *Blish, William G. Niles, Michigan, U.S.A.
1902. §Blount, Bertram. 2 Broadway, Westminster, S.W.
1888. ‡Bloxsom, Martin, B.A., Assoc.M.Inst.C.E. Hazelwood, Crumpsall Green, Manchester.
1870. ‡Blundell, Thomas Weld. Ince Blundell Hall, Great Crosby.
Blyth, B. Hall. 135 George-street, Edinburgh.
1885. ‡BLYTH, JAMES, M.A., F.R.S.E., Professor of Natural Philosophy in Anderson's College, Glasgow.
1867. *Blyth-Martin, W. Y. Blyth House, Newport, Fife.
1887. ‡Blythe, William S. 65 Mosley-street, Manchester.
1901. §BLYTHSWOOD, The Right Hon. Lord, LL.D. Blythswood, Renfrew.
1870. ‡Boardman, Edward. Oak House, Eaton, Norwich.
1887. *Boddington, Henry. Pownall Hall, Wilmslow, Manchester.
1900. ‡BODINGTON, Principal N., M.A. Yorkshire College, Leeds.
1889. ‡Bodmer, G. R., Assoc.M.Inst.C.E. 53 Victoria-street, S.W.
1884. ‡Body, Rev. C. W. E., M.A. Trinity College, Toronto, Canada.
1900. §Boileau, Major A. C. T., R.A. Royal Artillery Institution, Woolwich.
1887. *Boissevain, Gideon Maria. 4 Tesselschade-straat, Amsterdam.
1898. §BOLTON, H. The Museum, Queen's-road, Bristol.
1894. §Bolton, John. 15 Clifton-road, Crouch End, N.
1898. ‡Bolton, J. W. Baldwin-street, Bristol.
1898. §BONAR, J., M.A., LL.D. (Pres. F, 1898; Council 1899– 1 Redington-road, Hampstead, N.W.
1883. ‡Bonney, Frederic, F.R.G.S. Colton House, Rugeley, Staffordshire.

Year of Election.

1871. *BONNEY, Rev. THOMAS GEORGE, D.Sc., LL.D., F.R.S., F.S.A., F.G.S. (SECRETARY, 1881–85; Pres. C, 1886). 23 Denning-road, Hampstead, N.W.
1888. ‡Boon, William. Coventry.
1893. ‡Boot, Jesse. Carlyle House, 18 Burns-street, Nottingham.
1890. *BOOTH, CHARLES, D.Sc., F.R.S., F.S.S. 24 Great Cumberland-place, W.
1883. ‡Booth, James. Hazelhurst, Turton.
1883. ‡Booth, Richard. 4 Stone-buildings, Lincoln's Inn, W.C.
1876. ‡Booth, Rev. William H. Mount Nod-road, Streatham, S.W.
1883. ‡Boothroyd, Benjamin. Solihull, Birmingham.
1901. *Boothroyd, Herbert E. Sidney Sussex College, Cambridge.
1900. ‡Borchgrevink, C E. Lindfield, Sussex.
1876. *Borland, William. 260 West George-street, Glasgow.
1882. §Borns, Henry, Ph.D., F.C.S. 19 Alexandra-road, Wimbledon, Surrey.
1901. ‡Borradaile, L. A. Selwyn College, Cambridge.
1876. *BOSANQUET, R. H. M., M.A., F.R.S., F.R.A.S. Castillo Zamora, Realejo-Alto, Teneriffe.
1896. ‡Bose, Professor J. C., C.I.E., M.A., D.Sc. Calcutta, India.
*Bossey, Francis, M.D. Mayfield, Oxford-road, Redhill, Surrey.
1881. §BOTHAMLEY, CHARLES H., F.I.C., F.C.S., Director of Technical Instruction, Somerset County Education Committee. Hurst Knoll, Weston-super-Mare.
1887. ‡Bott, Dr. Owens College, Manchester.
1872. ‡Bottle, Alexander. 4 Godwyne-road, Dover.
1868. ‡Bottle, J. T. 28 Nelson-road, Great Yarmouth.
1887. ‡Bottomley, James, D.Sc., B.A. 220 Lower Broughton-road, Manchester.
1871. *BOTTOMLEY, JAMES THOMSON, M.A., D.Sc., F.R.S., F.R.S.E., F.C.S. 13 University-gardens, Glasgow.
1884. *Bottomley, Mrs. 13 University-gardens, Glasgow.
1892. ‡Bottomley, W. B., B.A., Professor of Botany in King's College, W.C.
1876. ‡Bottomley, William, jun. 15 University-gardens, Glasgow.
1890. ‡Boulnois, Henry Percy, M.Inst.C.E. 44 Campden House Court, Kensington, W.
1883. ‡Bourdas, Isaiah. Dunoon House, Clapham Common, S.W.
1883. ‡BOURNE, A. G., D.Sc., F.R.S., F.L.S., Professor of Biology in the Presidency College, Madras.
1893. *BOURNE, G. C., M.A., F.L.S. (Local Sec. 1894). Savile House, Mansfield-road, Oxford.
1866. ‡BOURNE, STEPHEN. 5 Lansdown-road, Lee, S.E.
1890. ‡Bousfield, C. E. 55 Clarendon-road, Leeds.
1902. §Bousfield, William. 20 Hyde Park-gate, W.
1898. ‡Bovey, Edward P., jun. Clifton-grove, Torquay.
1884. ‡BOVEY, HENRY T., M.A., F.R.S., M.Inst.C.E., Professor of Civil Engineering and Applied Mechanics in McGill University, Montreal. Ontario-avenue, Montreal, Canada.
1888. ‡Bowden, Rev. G. New Kingswood School, Lansdown, Bath.
1881. *BOWER, F. O., D.Sc., F.R.S., F.R.S.E., F.L.S. (Pres. K, 1898; Council 1900–), Regius Professor of Botany in the University of Glasgow.
1898. *Bowker, Arthur Frank, F.R.G.S., F.G.S. West Malling, Kent.
1856. *Bowlby, Miss F. E. 23 Lansdowne-parade, Cheltenham.
1898. §BOWLEY, A. L., M.A. Lynwood, Southern Hill, Reading.
1880. ‡Bowly, Christopher. Cirencester.
1887. ‡Bowly, Mrs. Christopher. Cirencester.

Year of Election.

1865. ‡Bowman, F. H., D.Sc., F.R.S.E. Mayfield, Knutsford, Cheshire.

1899. *Bowman, Herbert Lister, M.A., D.Sc. 13 Sheffield-gardens, Kensington, W.

1899. *Bowman, John Herbert. 13 Sheffield-gardens, Kensington, W.

1887. §Box, Alfred Marshall. Care of Messrs. Cooper, Box & Co., 69 Aldermanbury, E.C.

1895. *BOYCE, ROBERT, M.B., F.R.S., Professor of Pathology, University College, Liverpool.

1901. §Boyd, David T. Rhinsdale, Ballieston, Lanark.

1871. ‡Boyd, Thomas J. 41 Moray-place, Edinburgh.

1884. *Boyle, R. Vicars, C.S.I. Care of Messrs. Grindlay & Co., 55 Parliament-street, S.W.

1892. §BOYS, CHARLES VERNON, F.R.S. (Council, 1893–99). 27 The Grove, Boltons, S.W.

1872. *BRABROOK, E. W., C.B., F.S.A. (Pres. H, 1898). 178 Bedford-hill, Balham, S.W.

1869. *Braby, Frederick, F.G.S., F.C.S. Bushey Lodge, Teddington, Middlesex.

1894. *Braby, Ivon. Bushey Lodge, Teddington, Middlesex.

1893. §Bradley, F. L. Ingleside, Malvern Wells.

1899. *Bradley, J. W., Assoc.M.Inst.C.E. Town Hall, Wolverhampton.

1892. §Bradshaw, W. Carisbrooke House, The Park, Nottingham.

1863. ‡BRADY, GEORGE S., M.D., LL.D., F.R.S., Professor of Natural History in the Durham College of Science, Newcastle-on-Tyne. 2 Mowbray-villas, Sunderland.

1880. *Brady, Rev. Nicholas, M.A. Rainham Hall, Rainham, S.O., Essex.

1864. ‡*Braham, Philip. 3 Cobden-mansions, Stockwell-road, S.E.*

1888. §Braikenridge, W. J., J.P. 16 Royal-crescent, Bath.

1898. ‡Bramble, Lieut.-Colonel James R., F.S.A. Seafield, Weston-super-Mare.

1865. §BRAMWELL, Sir FREDERICK J., Bart., D.C.L., LL.D., F.R.S., M.Inst.C.E. (PRESIDENT, 1888; Pres. G, 1872, 1884; Council 1873–79, 1883–87). 5 Great George-street, S.W.

1867. ‡Brand, William. Milnefield, Dundee.

1861. *Brandreth, Rev. Henry. 72 Hills-road, Cambridge.

1885. *Bratby, William, J.P. Alton Lodge, Hale, Bowdon, Cheshire.

1902. §Braun, Henry C. 1 North-street, King's Cross, N.

1890. *Bray, George. Belmont, Wood-lane, Headingley, Leeds.

1868. ‡Bremridge, Elias. 17 Bloomsbury-square, W.C.

1877. ‡*Brent, Francis. 19 Clarendon-place, Plymouth.*

1902. *Brereton, Cloudesley. Breningham House, Melton Constable, Norfolk.

1898. §Brereton, Cuthbert A., M.Inst.C.E. 21 Delahay-street, S.W.

1882. *Bretherton, C. E. 12 The Paragon, Blackheath, S.E.

1866. ‡Brettell, Thomas. Dudley.

1891. ‡Brice, Arthur Montefiore, F.G.S., F.R.G.S. 28 Addison-mansions, Kensington, W.

1886. §BRIDGE, T. W., M.A., D.Sc., Professor of Zoology in the University, Birmingham.

1870. *Bridson, Joseph R. Holybourne, Alton, Hants.

1887. ‡Brierley, John, J.P. The Clough, Whitefield, Manchester.

1870. ‡Brierley, Joseph. New Market-street, Blackburn.

1886. ‡Brierley, Leonard. Somerset-road, Edgbaston, Birmingham.

1879. ‡Brierley, Morgan. Denshaw House, Saddleworth.

1870. *BRIGG, JOHN, M.P. Kildwick Hall, Keighley, Yorkshire.

1890. ‡Brigg, W. A. Kildwick Hall, Keighley, Yorkshire.

1893. ‡Bright, Joseph. Western-terrace, The Park, Nottingham.

Year of Election.

1868. ‡*Brine, Admiral Lindesay, F.R.G.S. United Service Club, Pall Mall, S.W.*
1893. ‡Briscoe, Albert E., B.Sc., A.R.C.Sc. Municipal Technical Institute, Romford-road, West Ham, E.
1884. ‡Brisette, M. H. 424 St. Paul-street, Montreal, Canada.
1898. ‡BRISTOL, The Right Rev. G. F. BROWNE, D.D., Lord Bishop of. 17 The Avenue, Clifton, Bristol.
1879. *BRITTAIN, W. H., J.P., F.R.G.S. Storth Oaks, Sheffield.
1878. ‡Britten, James, F.L.S. Department of Botany, British Museum, S.W.
1884. *Brittle, John R., M.Inst.C.E., F.R.S.E. 9 Vanbrugh-hill, Blackheath, S.E.
1899. ‡Broadwood, Miss Bertha M. Pleystowe, Capel, Surrey.
1899. ‡Broadwood, James H. E. Pleystowe, Capel, Surrey.
1897. ‡Brock, W. R. Toronto.
1896. *Brocklehurst, S. Olinda, Sefton Park, Liverpool.
1902. *Brodhurst, Mrs. T. Mary. 57 Upper Berkeley-street, Portman-square, W.
1883. *Brodie, David, M.D. 68 Hamilton-road, Highbury, N.
1901. §Brodie, T. G. Examination Hall, Victoria Embankment, W.C.
1884. ‡Brodie, William, M.D. 64 Lafayette-avenue, Detroit, Michigan, U.S.A.
1901. ‡Brodie, W. Brodie, M.D., F.R.S.E. 28 Hamilton Park-terrace, Hillhead, Glasgow.
1883. *Brodie-Hall, Miss W. L. 5 Devonshire-place, Eastbourne.
1881. ‡Brook, Robert G. Wolverhampton House, St. Helens, Lancashire.
1864. *Brooke, Ven. Archdeacon J. Ingham. The Vicarage, Halifax.
1887. §Brooks, James Howard. Elm Hirst, Wilmslow, near Manchester.
1863. ‡Brooks, John Crosse. 14 Lovaine-place, Newcastle-on-Tyne.
1887. ‡Brooks, S. H. Slade House, Levenshulme, Manchester.
1883. *Brotherton, E. A., M.P. Arthington Hall, Wharfedale, viâ Leeds.
1901. §Brough, Bennett H., F.I.C., F.G.S. 28 Victoria-street, S.W.; and Cranleigh House, near Addlestone, Surrey.
1883. *Brough, Mrs. Charles S. 12 Hillcrest-road, Sydenham, S.E.
1886. ‡Brough, Professor Joseph, LL.M., Professor of Logic and Philosophy in University College, Aberystwith.
1863. *BROWN, ALEXANDER CRUM, M.D., LL.D., F.R.S., F.R.S.E., V.P.C.S. (Pres. B, 1874; Local Sec. 1871), Professor of Chemistry in the University of Edinburgh. 8 Belgrave-crescent, Edinburgh.
1892. ‡Brown, Andrew, M.Inst.C.E. Messrs. Wm. Simons & Co., Renfrew, near Glasgow.
1896. ‡Brown, A. T. The Nunnery, St. Michael's Hamlet, Liverpool.
1867. ‡Brown, Sir Charles Gage, M.D., K.C.M.G. 88 Sloane-street, S.W.
1855. ‡Brown, Colin. 192 Hope-street, Glasgow.
1871. ‡Brown, David. Willowbrae House, Midlothian.
1863. *Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.
1883. ‡Brown, Mrs. Ellen F. Campbell. 27 Abercromby-square, Liverpool.
1881. ‡Brown, Frederick D. 26 St. Giles's-street, Oxford.
1883. ‡Brown, George Dransfield. Henley Villa, Ealing, Middlesex, W.
1883. *Brown, Mrs. H. Bienz. Overton, Crathes, Deeside, Aberdeen.
1883. ‡Brown, Mrs. Helen. Canaan-grove, Newbattle-terrace, Edinburgh.
1870. §BROWN, HORACE T., LL.D., F.R.S., F.G.S. (Pres. B, 1899). 52 Nevern-square, S.W.
1883. ‡Brown, Miss Isabella Spring. Canaan-grove, Newbattle-terrace, Edinburgh.

Year of Election.

1895. ‡BROWN, J. ALLEN, J.P., F.R.G.S., F.G.S. 7 Kent-gardens, Ealing, W.

1870. *BROWN, Professor J. CAMPBELL, D.Sc., F.C.S. University College, Liverpool.

1876. §BROWN, JOHN, F.R.S. (Local Sec. 1902). Longhurst, Dunmurry, Belfast.

1881. *Brown, John, M.D. 20 Warrender Park-crescent, Edinburgh.

1882. *Brown, John. 7 Second-avenue, Nottingham.

1895. *Brown, John Charles. 14 Baker-street, Nottingham.

1894. ‡Brown, J. H. 6 Cambridge-road, Brighton.

1882. *Brown, Mrs. Mary. 20 Warrender Park-crescent, Edinburgh.

1898. §Brown, Nicol, F.G.S. 4 The Grove, Highgate, N.

1897. ‡Brown, Price, M.B. 37 Carlton-street, Toronto, Canada.

1886. §Brown, R., R.N. Laurel Bank, Barnhill, Perth.

1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-upon-Tyne.

1897. ‡Brown, Richard. Jarvis-street, Toronto, Canada.

1901. §Brown, R. N. R., B.Sc. University College, Dundee.

1896. ‡Brown, Stewart H. Quarry Bank, Allerton, Liverpool.

1891. §BROWN, T. FORSTER, M.Inst.C.E. (Pres. G, 1891). Springfort, Stoke Bishop, Bristol.

1885. ‡Brown, W. A. The Court House, Aberdeen.

1884. ‡Brown, William George. Ivy, Albemarle Co., Virginia, U.S.A.

1863. ‡Browne, Sir Benjamin Chapman, M.Inst.C.E. Westacres, Newcastle-upon-Tyne.

1900. *Browne, Frank Balfour. The Cottage, Catfield, Great Yarmouth.

1892. ‡*Browne, Harold Crichton. Crindon, Dumfries.*

1895. *Browne, H. T. Doughty. 10 Hyde Park-terrace, W.

1879. ‡BROWNE, Sir J. CRICHTON, M.D., LL.D., F.R.S., F.R.S.E. 61 Carlisle-place-mansions, Victoria-street, S.W.

1891. ‡BROWNE, MONTAGU, F.G.S. Town Museum, Leicester.

1862. *Browne, Robert Clayton, M.A. Browne's Hill, Carlow, Ireland.

1872. ‡Browne, R. Mackley, F.G.S. Redcot, Bradbourne, Sevenoaks, Kent.

1902. §Browne, W. J. Templemore Park, Londonderry.

1865. ‡Browning, John, F.R.A.S. 63 Strand, W.C.

1883. ‡Browning, Oscar, M.A. King's College, Cambridge.

1902. §Bruce-Kingsmill, Captain J., R.A. Royal Arsenal, Woolwich.

1892. ‡Bruce, James. 10 Hill-street, Edinburgh.

1901. ‡Bruce, John. Inverallan, Helensburgh.

1893. ‡Bruce, William S. 11 Mount Pleasant, Joppa, Edinburgh.

1900. *Brumm, Charles. Lismara, Grosvenor-road, Birkdale, Southport.

1863. *Brunel, H. M., M.Inst.C.E. 21 Delahay-street, Westminster, S.W.

1875. †Brunlees, John, M.Inst.C.E. 12 Victoria-street, Westminster, S.W.

1896. *Brunner, Sir J. T., Bart., M.P. Druid's Cross, Wavertree, Liverpool.

1868. ‡BRUNTON, Sir T. LAUDER, M.D., D.Sc., F.R.S. 10 Stratford-place, Oxford-street, W.

1897. *Brush, Charles F. Cleveland, Ohio, U.S.A.

1878. ‡Brutton, Joseph. Yeovil.

1886. *BRYAN, G. H., D.Sc., F.R.S., Professor of Mathematics in University College, Bangor.

1894. ‡Bryan, Mrs. R. P. Plas Gwyn, Bangor.

1884. ‡BRYCE, Rev. Professor GEORGE. Winnipeg, Canada.

1897. ‡BRYCE, Right Hon. JAMES, D.C.L., M.P., F.R.S. 54 Portland-place, W.

1901. §Bryce, Thomas H. 2 Granby-terrace, Hillhead, Glasgow.

1894. ‡Brydone, R. M. Petworth, Sussex.

1890. §Bubb, Henry. Ullenwood, near Cheltenham.

1902. *Bubb, Miss E. Maude. Ullenwood, near Cheltenham.

Year of Election.
1871. §BUCHAN, ALEXANDER, M.A., LL.D., F.R.S., F.R.S.E., Sec. Scottish Meteorological Society. 42 Heriot-row, Edinburgh.
1867. ‡Buchan, Thomas. Strawberry Bank, Dundee.
1901. ‡Buchanan, James, M.D. 12 Hamilton-drive, Maxwell Park, Glasgow.
1881. *Buchanan, John H., M.D. Sowerby, Thirsk.
1871. ‡BUCHANAN, JOHN YOUNG, M.A., F.R.S., F.R.S.E., F.R.G.S., F.C.S. Christ's College, Cambridge.
1884. ‡Buchanan, W. Frederick. Winnipeg, Canada.
1902. *Buchanan, Miss, D.Sc. Birchvale, Brodrick, Isle of Man.
1883. ‡Buckland, Miss A. W. 5 Beaumont-crescent, West Kensington, W.
1886. *Buckle, Edmund W. 23 Bedford-row, W.C.
1886. ‡Buckley, Samuel. Merlewood, Beaver Park, Didsbury.
1884. *Buckmaster, Charles Alexander, M.A., F.C.S. 16 Heathfield-road, Mill Hill Park, W.
1851. *BUCKTON, GEORGE BOWDLER, F.R.S., F.L.S., F.C.S. Weycombe, Haslemere, Surrey.
1887. ‡Budenberg, C. F., B.Sc. Buckau Villa, Demesne-road, Whalley Range, Manchester.
1901. ‡Budgett, J. S. Trinity College, Cambridge.
1875. ‡Budgett, Samuel. Penryn, Beckenham, Kent.
1883. ‡Buick, Rev. George R., M.A. Cullybackey, Co. Antrim, Ireland.
1893. §BULLEID, ARTHUR, F.S.A. Glastonbury.
1871. ‡Bulloch, Matthew. 48 Prince's-gate, S.W.
1883. ‡Bulpit, Rev. W. T. Crossens Rectory, Southport.
1895. ‡Bunte, Dr. Hans. Karlsruhe, Baden.
1886. §BURBURY, S. H., M.A., F.R.S. 1 New-square, Lincoln's Inn, W.C.
1842. *Burd, John. Glen Lodge, Knocknerea, Sligo.
1869. ‡Burdett-Coutts, Baroness. 1 Stratton-street, Piccadilly, W.
1881. ‡Burdett-Coutts, William Lehmann, M.P. 1 Stratton-street, Piccadilly, W.
1891. ‡Burge, Very Rev. T. A. Ampleforth Cottage, near York.
1894. ‡BURKE, JOHN B. B. Trinity College, Cambridge.
1884. *Burland, Lieut.-Col. Jeffrey H. 824 Sherbrook-street, Montreal, Canada.
1899. ‡Burls, Herbert T. Care of Messrs. H. S. King & Co., Cornhill, E.C.
1888. ‡Burne, H. Holland. 28 Marlborough-buildings, Bath.
1883. *Burne, Major-General Sir Owen Tudor, G.C.I.E., K.C.S.I., F.R.G.S. 132 Sutherland-gardens, Maida Vale, W.
1876. ‡Burnet, John. 14 Victoria-crescent, Dowanhill, Glasgow.
1885. *Burnett, W. Kendall, M.A. Migvie House, North Silver-street, Aberdeen.
1877. ‡Burns, David. Alston, Carlisle.
1884. ‡Burns, Professor James Austin. Southern Medical College, Atlanta, Georgia, U.S.A.
1899. ‡Burr, Malcolm. Dorman's Park, East Grinstead.
1887. ‡Burroughs, Eggleston, M.D. Snow Hill-buildings, E.C.
1860. ‡Burrows, Montague, M.A. Oxford.
1894. ‡Burstall, H. F. W. 76 King's-road, Camden-road, N.W.
1891. ‡Burt, J. J. 103 Roath-road, Cardiff.
1888. ‡Burt, Sir John Mowlem. 3 St. John's-gardens, Kensington, W.
1888. ‡Burt, Lady. 3 St. John's-gardens, Kensington, W.
1894. ‡Burton, Charles V. 24 Wimpole-street, W.
1866. *BURTON, FREDERICK M., F.L.S., F.G.S. Highfield, Gainsborough, Lincolnshire.
1889. ‡Burton, Rev. R. Lingen. Little Aston, Sutton Coldfield.
1897. ‡Burton, S. H., M.B. 50 St. Giles's-street, Norwich.

Year of Election.

1892. ‡Burton-Brown, Colonel Alexander, R.A., F.R.A.S., F.G.S. 11 Union-crescent, Margate.
1897. ‡Burwash, Rev. N., LL.D., Principal of Victoria University, Toronto, Canada.
1887. *Bury, Henry. Mayfield House, Farnham, Surrey.
1899. §Bush, Anthony. 43 Portland-road, Nottingham.
1895. §Bushe, Colonel C. K., F.G.S. 19 Cromwell-road, S.W.
1878. ‡*BUTCHER, J. G., M.A. 22 Collingham-place, S.W.*
1884. *Butcher, William Deane, M.R.C.S.Eng. Holyrood, 5 Cleveland-road, Ealing, W.
1884. ‡Butler, Matthew I. Napanee, Ontario, Canada.
1884. *Butterworth, W. Park-avenue, Temperley, near Manchester.
1872. ‡Buxton, Charles Louis. Cromer, Norfolk.
1887. *Buxton, J. H. Clumber Cottage, Montague-road, Felixstowe.
1881. ‡Buxton, Sydney C., M.P. 15 Eaton-place, S.W.
1868. ‡Buxton, S. Gurney. Catton Hall, Norwich.
1872. ‡Buxton, Sir Thomas Fowell, Bart., G.C.M.G., F.R.G.S. Warlies, Waltham Abbey, Essex.
1854. ‡BYERLEY, ISAAC, F.L.S. 22 Dingle-lane, Toxteth Park, Liverpool.
1899. §Byles, Arthur R. 'Bradford Observer,' Bradford, Yorkshire.
1852. ‡Byrne, Very Rev. James. Ergenagh Rectory, Omagh.
1883. ‡Byrom, John R. Mere Bank, Fairfield, near Manchester.

1889. ‡Cackett, James Thoburn. 60 Larkspur-terrace, Newcastle-upon-Tyne.
1892. ‡Cadell, Henry M., B.Sc., F.R.S.E. Grange, Bo'ness, N.B.
1894. ‡Caillard, Miss E. M. Wingfield House, near Trowbridge, Wilts.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1861. *Caird, James Key. 8 Roseangle, Dundee.
1901. ‡Caldwell, Hugh. Blackwood, Newport, Monmouthshire.
1868. ‡Caley, A. J. Norwich.
1887. ‡CALLAWAY, CHARLES, M.A., D.Sc., F.G.S. 16 Montpellier-villas, Cheltenham.
1897. §CALLENDAR, Prof. HUGH L., M.A., F.R.S. (Council, 1900-). 2 Chester-place, Regent's Park, N.W.
1892. ‡Calvert, A. F., F.R.G.S. Royston, Eton-avenue, N.W.
1901. ‡Calvert, H. T. Roscoe-terrace, Armley, Leeds.
1884. ‡Cameron, Æneas. Yarmouth, Nova Scotia, Canada.
1857. ‡CAMERON, Sir CHARLES A., C.B., M.D. 15 Pembroke-road, Dublin.
1896. §Cameron, Irving H. 307 Sherbourne-street, Toronto, Canada.
1884. ‡Cameron, James C., M.D. 41 Belmont-park, Montreal, Canada.
1870. †Cameron, John, M.D. 17 Rodney-street, Liverpool.
1901. §Campbell, Archibald. Springfield Quay, Glasgow.
1884. ‡Campbell, Archibald H. Toronto, Canada.
1876. ‡Campbell, Right Hon. James A., LL.D., M.P. Stracathro House, Brechin.
Campbell, John Archibald, M.D., F.R.S.E. Albyn-place, Edinburgh.
1897. ‡Campbell, Major J. C. L. New Club, Edinburgh.
1901. †Campbell, M. Pearce. 9 Lynedoch-crescent, Glasgow.
1898. ‡*Campbell, Mrs. Napier.* 81 *Ashley-gardens, S.W.*
1902. §Campbell, Robert. 21 Great Victoria-street, Belfast.
1897. †Campion, B. W. Queen's College, Cambridge.
1882. ‡Candy, F. H. 71 High-street, Southampton.
1890. ‡CANNAN, EDWIN, M.A., LL.D., F.S.S. (Pres. F, 1902). 1 Wellington-square, Oxford.

Year of Election.

1897. §Cannon, Herbert. Woodbank, Erith, Kent.
1888. ‡Cappel, Sir Albert J. L., K.C.I.E. 27 Kensington Court-gardens, W.
1894. §CAPPER, D. S., M.A., Professor of Mechanical Engineering in King's College, W.C.
1887. ‡CAPSTICK, JOHN WALTON. Trinity College, Cambridge.
1873. *CARBUTT, Sir EDWARD HAMER, Bart., M.Inst.C.E. 19 Hyde Park-gardens, W.
1896. **Carden, H. V. Balinveney, Bookham, Surrey.*
1901. §Cargill, David Sime. 9 Park-terrace, Glasgow.
1877. ‡Carkeet, John. 3 St. Andrew's-place, Plymouth.
1898. ‡Carlile, George M. 7 Upper Belgrave-road, Bristol.
1901. ‡Carlile, W. Warrand. Harlie, Largs, Ayrshire.
1867. ‡Carmichael, David (Engineer). Dundee.
1876. ‡Carmichael, Niel, M.D. 177 Nitherdale-road, Pollokshields, Glasgow.
1897. ‡Carmichael, Norman R. Queen's University, Kingston, Ontario, Canada.
1884. ‡Carnegie, John. Peterborough, Ontario, Canada.
1902. §Carpenter, G. H., B.Sc. Science and Art Museum, Dublin.
1884. ‡Carpenter, Louis G. Agricultural College, Fort Collins, Colorado, U.S.A.
1897. ‡Carpenter, R. C. Cornell University, Ithaca, New York, U.S.A.
1889. ‡Carr, Cuthbert Ellison. Hedgeley, Alnwick.
1893. ‡CARR, J. WESLEY, M.A., F.L.S., F.G.S., Professor of Biology in University College, Nottingham.
1889. ‡Carr-Ellison, John Ralph. Hedgeley, Alnwick.
1867. ‡CARRUTHERS, WILLIAM, F.R.S., F.L.S., F.G.S. (Pres. D, 1886). 14 Vermont-road, Norwood, S.E.
1886. ‡CARSLAKE, J. BARHAM (Local Sec. 1886). 30 Westfield-road, Birmingham.
1899. §Carslaw, H. S., D.Sc., Professor of Mathematics in the University of Sydney, N.S.W.
1883. ‡Carson, John. 41 Royal-avenue, Belfast.
1868. *Carteighe, Michael, F.C.S., F.I.C. 180 New Bond-street, W.
1897. ‡Carter, E. Tremlett. 'The Electrician,' Salisbury-court, Fleet-street, E.C.
1866. ‡*Carter, H. H. The Park, Nottingham.*
1870. ‡Carter, Dr. William. 78 Rodney-street, Liverpool.
1900. *Carter, Rev. W. Lower, M.A., F.G.S. Hopton, Mirfield.
1896. §Cartwright, Miss Edith G. 21 York Street-chambers, Bryanston-square, W.
1878. *Cartwright, Ernest H., M.A., M.D. 1 Bower-terrace, Maidstone.
1870. §Cartwright, Joshua, M.Inst.C.E., F.S.I. Peel-chambers, Market-place, Bury, Lancashire.
1862. ‡Carulla, F. J. R. 84 Argyll-terrace, Derby.
1894. ‡Carus, Paul. La Salle, Illinois, U.S.A.
1884. *Carver, Rev. Canon Alfred J., D.D., F.R.G.S. Lynnhurst, Streatham Common, S.W.
1884. ‡Carver, Mrs. Lynnhurst, Streatham Common, S.W.
1901. ‡Carver, Thomas A. B., B.Sc., Assoc. M.Inst.C.E. 118 Napiershall-street, Glasgow.
1887. ‡Casartelli, Rev. L. C., M.A., Ph.D. St. Bede's College, Manchester.
1899. *Case, J. Monckton. Hampden Club, Phœnix-street, N.W.
1897. *Case, Willard E. Auburn, New York, U.S.A.
1896. *Casey, James. 10 Philpot-lane, E.C.
1871. ‡Cash, Joseph. Bird-grove, Coventry.
1873. *Cash, William, F.G.S. 35 Commercial-street, Halifax.

Year of Election.

1900. *Cassie, W., M.A. Professor of Physics in the Royal Holloway College. Brantwood, Englefield Green.
1897. ‡Caston, Harry Edmonds Featherston. 340 Brunswick-avenue, Toronto, Canada.
1874. ‡Caton, Richard, M.D. Lea Hall, Gateacre, Liverpool.
1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1886. *Cave-Moyles, Mrs. Isabella. 4 Crescent-terrace, Cheltenham.
Cayley, Digby. Brompton, near Scarborough.
Cayley, Edward Stillingfleet. Wydale, Malton, Yorkshire.
1883. ‡*Chadwick, James Percy.* 51 *Alexandra-road, Southport.*
1859. ‡Chalmers, John Inglis. Aldbar, Aberdeen.
1884. ‡Chamberlain, Montague. St. John, New Brunswick, Canada.
1901. §Chamen, W. A. 66 Partickhill-road, Glasgow.
1881. *Champney, John E. 27 Hans-place, S.W.
1865. ‡Chance, A. M. Edgbaston, Birmingham.
1865. ‡Chance, Robert Lucas. Chad Hill, Edgbaston, Birmingham.
1888. ‡Chandler, S. Whitty, B.A. Sherborne, Dorset.
1902. §Chapman, D. L. 10 Parsonage-road, Withington, Manchester.
1861. *Chapman, Edward, M.A., M.P., F.L.S., F.C.S. Hill End, Mottram, Manchester.
1897. ‡Chapman, Edward Henry. 17 St. Hilda's-terrace, Whitby.
1889. ‡Chapman, L. H. 147 Park-road, Newcastle-upon-Tyne.
1884. ‡Chapman, Professor. University College, Toronto, Canada.
1899. §Chapman, Professor Sydney John, M.A. The Owens College, Manchester.
1877. ‡Chapman, T. Algernon, M.D. 17 Wesley-avenue, Liscard, Cheshire
1874. ‡Charles, J. J., M.D., Professor of Anatomy and Physiology in Queen's College, Cork. Newmarket, Co. Cork.
1874. ‡Charley, William. Seymour Hill, Dunmurry, Ireland.
1886. ‡Chate, Robert W. Southfield, Edgbaston, Birmingham.
1884. *CHATTERTON, GEORGE, M.A., M.Inst.C.E. 6 The Sanctuary, Westminster, S.W.
1886. *CHATTOCK, A. P., M.A., Professor of Experimental Physics in University College, Bristol.
1867. *Chatwood, Samuel, F.R.G.S. High Lawn, Broad Oak Park, Worsley, Manchester.
1884. ‡CHAUVEAU, The Hon. Dr. Montreal, Canada.
1883. ‡Chawner, W., M.A. Emmanuel College, Cambridge.
1864. ‡CHEADLE, W. B., M.A., M.D., F.R.G.S. 19 Portman-street, Portman-square, W.
1900. §Cheesman, W. Norwood. The Crescent, Selby.
1887. ‡Cheetham, F. W. Limefield House, Hyde.
1887. ‡Cheetham, John. Limefield House, Hyde.
1896. ‡Chenie, John. Charlotte-street, Edinburgh.
1874. *Chermside, Major-General Sir H. C., R.E., G.C.M.G., C.B. Care of Messrs. Cox & Co., Craig's-court, Charing Cross, S.W.
1884. ‡Cherriman, Professor J. B. Ottawa, Canada.
1896. ‡Cherry, R. B. 92 Stephen's-green, Dublin.
1879. *Chesterman, W. Belmayne, Sheffield.
1883. ‡Chinery, Edward F. Monmouth House, Lymington.
1884. ‡Chipman, W. W. L. 957 Dorchester-street, Montreal, Canada.
1889. ‡Chirney, J. W. Morpeth.
1894. ‡CHISHOLM, G. G., M.A., B.Sc., F.R.G.S. 59 Drakefield-road, Upper Tooting, S.W
1900. ‡CHISHOLM, Sir SAMUEL. Glasgow.
1899. §Chitty, Edward. Sonnenberg, Castle Avenue, Dover.
1899. §Chitty, Mrs. Edward. Sonnenberg, Castle Avenue, Dover.

Year of Election.

1899. §Chitty, G. W. Mildura, Park-avenue, Dover.
1882. ‡Chorley, George. Midhurst, Sussex.
1887. ‡*Chorlton, J. Clayton. New Holme, Withington, Manchester.*
1893. *CHREE, CHARLES, D.Sc., F.R.S. Kew Observatory, Richmond, Surrey.
1900. *Christie, R. J. Duke Street, Toronto, Canada.
1884. *Christie, William. 29 Queen's-park, Toronto, Canada.
1875. *Christopher, George, F.C.S. May Villa, Lucien-road, Tooting Common, S.W.
1876. *CHRYSTAL, GEORGE, M.A., LL.D., F.R.S.E. (Pres. A, 1885), Professor of Mathematics in the University of Edinburgh. 5 Belgrave-crescent, Edinburgh.
1870. §CHURCH, A. H., M.A., F.R.S., F.S.A., Professor of Chemistry in the Royal Academy of Arts. Shelsley, Ennerdale-road, Kew.
1898. §CHURCH, Colonel G. EARL, F.R.G.S. (Pres. E, 1898). 216 Cromwell-road, S.W.
1860. ‡CHURCH, Sir WILLIAM SELBY, Bart., M.D. St. Bartholomew's Hospital, E.C.
1896. ‡Clague, Daniel, F.G.S. 5 Sandstone-road, Stoneycroft, Liverpool.
1901. §Clark, Archibald B., M.A. 2 Woodburn-place, Edinburgh.
1876. ‡Clark, David R., M.A. 8 Park-drive West, Glasgow.
1890. ‡Clark, E. K. 13 Wellclose-place, Leeds.
1877. *Clark, F. J., J.P., F.L.S. Netherleigh, Street, Somerset.
1902. §Clark, G. M. Cape Town.
Clark, George T. 44 Berkeley-square, W.
1892. ‡Clark, James. Chapel House, Paisley.
1901. ‡Clark, James M., M.A., B.Sc. 8 Park-drive West, Glasgow.
1876. ‡Clark, Dr. John. 138 Bath-street, Glasgow.
1881. ‡Clark, J. Edmund, B.A., B.Sc. 112 Wool Exchange, E.C.
1901. *Clark, Robert M., B.Sc., F.L.S. 27 Albyn-place, Aberdeen.
1855. ‡Clark, Rev. William, M.A. Beechcroft, Jordan-hill, Glasgow.
1887. §Clarke, C. Goddard, J.P. South Lodge, Champion Hill, S.E.
1875. ‡Clarke, Charles S. 4 Worcester-terrace, Clifton, Bristol.
1886. ‡Clarke, David. Langley-road, Small Heath, Birmingham.
1886. ‡Clarke, Rev. H. J. Great Barr Vicarage, Birmingham.
1875. ‡CLARKE, JOHN HENRY (Local Sec. 1875). 4 Worcester-terrace, Clifton, Bristol.
1902. §Clarke, Miss L. J., B.Sc. Hampden House, Crouch End, N.
1897. ‡*Clarke, Colonel S. C., R.E. Parklands, Caversham, near Reading.*
1896. ‡Clarke, W. W. Albert Dock Office, Liverpool.
1884. ‡Claxton, T. James. 461 St. Urbain-street, Montreal, Canada.
1889. *CLAYDEN, A. W., M.A., F.G.S. St. John's, Polsloe-road, Exeter.
1890. *Clayton, William Wikely. Gipton Lodge, Leeds.
1861. §CLELAND, JOHN, M.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 2 The University, Glasgow.
1902. §Clements, Olaf P. Tana, St. Bernard's-road, Olton, Warwick.
1861. *CLIFTON, R. BELLAMY, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. 3 Bardwell-road, Banbury-road, Oxford.
1898. ‡Clissold, H. 30 College-road, Clifton, Bristol.
1893. ‡Clofford, William. 36 Mansfield-road, Nottingham.
Clonbrock, Lord Robert. Clonbrock, Galway.
1878. §Close, Rev. Maxwell H., F.G.S. 38 Lower Baggot-street, Dublin.
1873. ‡Clough, John. Bracken Bank, Keighley, Yorkshire.
1892. ‡Clouston, T. S., M.D. Tipperlinn House, Edinburgh.
1883. *CLOWES, FRANK, D.Sc., F.C.S. (Local Sec. 1893). The Grange, College-road, Dulwich, S.E.
1885. ‡Clyne, James. Rubislaw Den South, Aberdeen.

Year of
Election.

1891. *Coates, Henry. Pitcullen House, Perth.
1897. ‡Coates, J., M.Inst.C.E. 99 Queen-street, Melbourne, Australia.
1901. ‡Coats, Allan. Hayfield, Paisley.
1884. §Cobb, John. Fitzherries, Abingdon.
1895. ***Cobbold, Felix T.**, M.A. The Lodge, Felixstowe, Suffolk.
1889. ‡Cochrane, Cecil A. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1864. *Cochrane, James Henry. Burston House, Pittville, Cheltenham.
1889. ‡Cochrane, William. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1892. ‡*Cockburn, John. Glencorse House, Milton Bridge, Edinburgh.*
1901. ‡Cockburn, Sir John, K.C.M.G., M.D. 10 Gatestone-road, Upper Norwood, S.E.
1883. ‡Cockshott, J. J. 24 Queen's-road, Southport.
1861. *Coe, Rev. Charles C., F.R.G.S. Whinsbridge, Grosvenor-road, Bournemouth.
1898. ‡Coffey, George. 5 Harcourt-terrace, Dublin.
1881. ***Coffin, Walter Harris**, F.C.S. 94 Cornwall-gardens, South Kensington, S.W.
1896. *Coghill, Percy de G. 4 Sunnyside, Prince's Park, Liverpool.
1884. *Cohen, B. L., M.P. 30 Hyde Park-gardens, W.
1887. ‡Cohen, Julius B. Yorkshire College, Leeds.
1901. §Cohen, N. L. 11 Hyde Park-terrace, W.
1901. *Cohen, R. Waley. 11 Hyde Park-terrace, W.
1894. *Colby, Miss E. L., B.A. Carregwen, Aberystwyth.
1895. *Colby, James George Ernest, M.A., F.R.C.S. Malton, Yorkshire.
1895. *Colby William Henry. Carregwen, Aberystwyth.
1893. ‡Cole, Professor Grenville A. J., F.G.S. Royal College of Science, Dublin.
1879. ‡Cole, Skelton. 387 Glossop-road, Sheffield.
1864. ‡Colefax, H. Arthur, Ph.D., F.C.S. 14 Chester-terrace, Chester-square, S.W.
1897. §**Coleman**, Dr. A. P. 476 Huron-street, Toronto, Canada.
1893. ‡Coleman, J. B., F.C.S., A.R.C.S. University College, Nottingham.
1899. §Coleman, William. The Shrubbery, Buckland, Dover.
1878. ‡Coles, John. 1 Savile-row, W.
1854. *Colfox, William, B.A. Westmead, Bridport, Dorsetshire.
1899. §Collard, George. The Gables, Canterbury.
1892. ‡Collet, Miss Clara E. 7 Coleridge-road, N.
1892. ‡Collie, Alexander. Harlaw House, Inverurie.
1887. ‡**Collie, J. Norman**, Ph.D., F.R.S., Professor of Organic Chemistry in the University of London. 16 Campden-grove, W.
1869. ‡Collier, W. F. Woodtown, Horrabridge, South Devon.
1893. ‡Collinge, Walter E. The University, Birmingham.
1861. *Collingwood, J. Frederick, F.G.S. 5 Irene-road, Parson's Green, S.W.
1876. ‡**Collins, J. H.**, F.G.S. 162 Barry-road, S.E.
1865. *Collins, James Tertius. Churchfield, Edgbaston, Birmingham.
1902. §Collins, T. R. Belfast Royal Academy, Belfast.
1882. ‡Colmer, Joseph G., C.M.G. Office of the High Commissioner for Canada, 17 Victoria-street, S.W.
1884. ‡Colomb, Sir J. C. R., M.P., F.R.G.S. Dromquinna, Kenmare, Kerry, Ireland; and Junior United Service Club, S.W.
1897. ‡Colquhoun, A. H. U., B.A. 39 Borden-street, Toronto, Canada.
1896. *Comber, Thomas, F.L.S. Leighton, Parkgate, Chester.
1888. ‡Commans, R. D. Macaulay-buildings, Bath.
1884. ‡**Common, A. A.**, LL.D., F.R.S., F.R.A.S. 63 Eaton-rise, Ealing, W.
1891. ‡*Common, J. F. F. 21 Park-place, Cardiff.*
1900. ‡Common, T. A., B.A. 63 Eaton-rise, Ealing, W.

Year of Election.

1892. ‡Comyns, Frank, M.A., F.C.S. The Grammar School, Durham.
1884. ‡Conklin, Dr. William A. Central Park, New York, U.S.A.
1896. ‡Connacher, W. S. Birkenhead Institute, Birkenhead.
1890. ‡Connon, J. W. Park-row, Leeds.
1871. *Connor, Charles C. 4 Queen's Elms, Belfast.
1902. §Conway, A. W. 100 Leinster-road, Rathmines, Dublin.
1893. ‡**Conway**, Professor Sir W. M., M.A., F.R.G.S. The Red House, Hornton-street, W.
1899. ‡**Coode, J. Charles**, M.Inst.C.E. Westminster-chambers, 9 Victoria-street, S.W.
1898. §Cook, Ernest H. 27 Berkeley-square, Clifton, Bristol.
1900. ‡Cook, Walter. 98 St. Mary's-street, Cardiff.
1882. ‡**Cooke**, Major-General A. C., R.E., C.B., F.R.G.S. Palace-chambers, Ryder-street, S.W.
1876. ***Cooke, Conrad** W. 28 Victoria-street, S.W.
1881. ‡Cooke, F. Bishopshill, York.
1868. ‡Cooke, Rev. George H. Wanstead Vicarage, near Norwich.
1868. ‡**Cooke**, M. C., M.A. 53 Castle-road, Kentish Town, N.W.
1884. ‡Cooke, R. P. Brockville, Ontario, Canada.
1881. ‡Cooke, Thomas. Bishopshill, York.
1896. ‡Cookson, E. H. Kiln Hey, West Derby.
1899. *Coomáraswámy, A. K., B.Sc., F.L.S., F.G.S. Walden, Worplesdon, Guildford.
1902. *Coomáraswámy, Mrs. A. K. Walden, Worplesdon, Guildford.
1895. ‡Cooper, Charles Friend, M.I.E.E. 68 Victoria-street, Westminster, S.W.
1901. *Cooper, C. Forster, B.A. Trinity College, Cambridge.
1893. ‡Cooper, F. W. 14 Hamilton-road, Sherwood Rise, Nottingham.
1868. ‡Cooper, W. J. New Malden, Surrey.
1889. ‡Coote, Arthur. The Minories, Jesmond, Newcastle-upon-Tyne.
1878. ‡Cope, Rev. S. W. Bramley, Leeds.
1871. ‡**Copeland, Ralph**, Ph.D., F.R.A.S., Astronomer Royal for Scotland and Professor of Astronomy in the University of Edinburgh.
1881. ‡Copperthwaite, H. Holgate Villa, Holgate-lane, York.
1901. §Corbett, A. Cameron, M.P. Thornliebank House, Glasgow.
1891. ‡Corbett, E. W. M. Y Fron, Pwllypant, Cardiff.
1887. *Corcoran, Bryan. Fairlight, 22 Oliver-grove, South Norwood, S.E.
1894. §Corcoran, Miss Jessie R. The Chestnuts, Mulgrave-road, Sutton, Surrey.
1883. *Core, Professor Thomas H., M.A. Fallowfield, Manchester.
1870. ***Corfield**, W. H., M.A., M.D., F.C.S., F.G.S., Professor of Hygiene and Public Health in University College, London. 19 Savile-row, W.
1901. *Cormack, Professor J. D., B.Sc. University College, Gower-street, W.C.
1893. *Corner, Samuel, B.A., B.Sc. 95 Forest-road West, Nottingham.
1889. ‡**Cornish, Vaughan**, D.Sc., F.R.G.S. 72 Prince's-square, W.
1884. *Cornwallis, F. S. W., M.P., F.L.S. Linton Park, Maidstone.
1885. ‡Corry, John. Rosenheim, Park Hill-road, Croydon.
1888. ‡Corser, Rev. Richard K. 57 Park Hill-road, Croydon.
1900. §Cortie, Rev. A. L., F.R.A.S. Stonyhurst College, Blackburn.
1891. ‡Cory, John, J.P. Vaindre Hall, near Cardiff.
1891. ‡Cory, Alderman Richard, J.P. Oscar House, Newport-road, Cardiff.
1891. **Cotsworth, Haldane Gwilt. The Cedars, Cobham-road, Norbiton, S.W.*
1874. ***Cotterill**, J. H., M.A., F.R.S. 15 St. Alban's-mansions, Kensington Court-gardens, W.

Year of Election.
1876. ‡Couper, James. City Glass Works, Glasgow.
1876. ‡Couper, James, jun. City Glass Works, Glasgow.
1896. ‡COURTNEY, Right Hon. LEONARD (Pres. F, 1896). 15 Cheyne-walk, Chelsea, S.W.
1890. ‡Cousins, John James. Allerton Park, Chapel Allerton, Leeds.
1896. ‡Coventry, J. 19 Sweeting-street, Liverpool.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1863. ‡Cowan, John A. Blaydon Burn, Durham.
1863. ‡Cowan, Joseph, jun. Blaydon, Durham.
1872. *Cowan, Thomas William, F.L.S., F.G.S. 17 King William-street, Strand, W.C.
1900. §Cowburn, Henry. Dingle Head, Westleigh, Leigh, Lancashire.
1895. *COWELL, PHILIP H., M.A. Royal Observatory, Greenwich, and 74 Vanbrugh-park, Blackheath, S.E.
1899. ‡Cowper-Coles, Sherard. 82 Victoria-street, S.W.
1867. *Cox, Edward. Cardean, Meigle, N.B.
1892. ‡Cox, Robert. 34 Drumsheugh-gardens, Edinburgh.
1882. ‡Cox, Thomas A., District Engineer of the S., P., and D. Railway, Lahore, Punjab. Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1888. ‡Cox, Thomas W. B. The Chestnuts, Lansdowne, Bath.
1867. ‡Cox, William. Foggley, Lochee, by Dundee.
1890. ‡Cradock, George. Wakefield.
1892. *Craig, George A. Post Office, Mooroopna, Victoria, Australia.
1902. §Craig, H. C. Strandtown, Belfast.
1884. §CRAIGIE, Major P. G., C.B., F.S.S. (Pres. F, 1900). 6 Lyndhurst-road, Hampstead, N.W.
1876. ‡Cramb, John. Larch Villa, Helensburgh, N.B.
1884. ‡Crathern, James. Sherbrooke-street, Montreal, Canada.
1887. ‡*Craven, John. Smedley Lodge, Cheetham, Manchester.*
1887. *Craven, Thomas, J.P. Woodheyes Park, Ashton-upon-Mersey.
1871. *CRAWFORD AND BALCARRES, The Right Hon. the Earl of, K.T., LL.D., F.R.S., F.R.A.S. (VICE-PRESIDENT, 1903). 2 Cavendish-square, W.; and Haigh Hall, Wigan.
1871. *Crawford, William Caldwell, M.A. 1 Lockharton-gardens, Colinton-road, Edinburgh.
1846. *Crawshaw, The Right Hon. Lord. Whatton, Loughborough.
1890. §Crawshaw, Charles B. Rufford Lodge, Dewsbury.
1883. *Crawshaw, Edward, F.R.G.S. 25 Tollington-park, N.
1870. *Crawshay, Mrs. Robert. Caversham Park, Reading.
1885. §CREAK, Captain E. W., C.B., R.N., F.R.S. (Council 1896–). 9 Hervey-road, Blackheath, S.E.
1901. ‡Cree, T. S. 15 Montgomerie-quadrant, Glasgow.
1896. ‡Cregeen, A. C. 21 Prince's-avenue, Liverpool.
1879. ‡Creswick, Nathaniel. Chantry Grange, near Sheffield.
1876. *Crewdson, Rev. Canon George. St. Mary's Vicarage, Windermere.
1887. *Crewdson, Theodore. Norcliffe Hall, Handforth, Manchester.
1896. §Crichton, Hugh. 6 Rockfield-road, Anfield, Liverpool.
1880. *Crisp, Frank, B.A., LL.B., F.L.S., F.G.S. 5 Lansdowne-road, Notting Hill, W.
1890. *Croft, W. B., M.A. Winchester College, Hampshire.
1878. ‡Croke, John O'Byrne, M.A. Clouneagh, Ballingarry-Lacy, Co Limerick.
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1885. ‡CROMBIE, J. W., M.A., M.P. (Local Sec. 1885). Balgownie Lodge, Aberdeen.
1885. ‡Crombie, Theodore. 18 Albyn-place, Aberdeen.

Year of Election.

1901. ‡CROMPTON, Colonel, R. E., C.B., M.Inst.C.E. (Pres. G, 1901). Kensington Court, W.
1887. ‡CROOK, HENRY T., M.Inst.C.E. 9 Albert-square, Manchester.
1898. §Crooke, William. Langton House, Charlton Kings, Cheltenham.
1865. §CROOKES, Sir WILLIAM, F.R.S., V.P.C.S. (PRESIDENT, 1898; Pres. B, 1886; Council 1885-91). 7 Kensington Park-gardens, W.
1879. ‡Crookes, Lady. 7 Kensington Park-gardens, W.
1897. *CROOKSHANK, E. M., M.B. Ashdown Forest, Forest Row, Sussex.
1870. ‡Crosfield, C. J. Gledhill, Sefton Park, Liverpool.
1894. *Crosfield, Miss Margaret C. Undercroft, Reigate.
1870. *CROSFIELD, WILLIAM. 3 Fulwood-park, Liverpool.
1890. ‡Cross, E. Richard, LL.B. Harwood House, New Parks-crescent, Scarborough.
1853. ‡Crosskill, William. Beverley, Yorkshire.
1887. *Crossley, William J. Glenfield, Bowdon, Cheshire.
1894. *Crosweller, William Thomas, F.Z.S., F.I.Inst. Kent Lodge, Sidcup, Kent.
1897. *Crosweller, Mrs. W. T. Kent Lodge, Sidcup, Kent.
1894. ‡*Crow, C. F. Home Lea, Woodstock Road, Oxford.*
1883. ‡Crowder, Robert. Stanwix, Carlisle.
1882. §Crowley, Frederick. Ashdell, Alton, Hampshire.
1890. *Crowley, Ralph Henry, M.D. 116 Manningham-lane, Bradford.
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-upon-Tyne.
1885. ‡Cruickshank, Alexander, LL.D. 20 Rose-street, Aberdeen.
1888. ‡Crummack, William J. London and Brazilian Bank, Rio de Janeiro, Brazil.
1898. ‡CRUNDALL, Sir WILLIAM H. Dover.
1888. ‡Culley, Robert. Bank of Ireland, Dublin.
1883. *CULVERWELL, EDWARD P., M.A. 40 Trinity College, Dublin.
1883. ‡Culverwell, T. J. H. Litfield House, Clifton, Bristol.
1897. ‡Cumberland, Barlow. Toronto, Canada.
1898. §Cundall, J. Tudor. 1 Dean Park-crescent, Edinburgh.
1861. *Cunliffe, Edward Thomas. The Parsonage, Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. Dunedin, Handforth, Manchester.
1882. *CUNNINGHAM, Lieut.-Colonel ALLAN, R.E., A.I.C.E. 20 Essex-villas Kensington, W.
1877. *CUNNINGHAM, D. J., M.D., D.C.L., F.R.S., F.R.S.E. (Pres. H, 1901; Council, 1902-), Professor of Anatomy in the University of Edinburgh.
1891. ‡Cunningham, J. H. 2 Ravelston-place, Edinburgh.
1852. ‡Cunningham, John. Macedon, near Belfast.
1885. ‡CUNNINGHAM, J. T., B.A. Biological Laboratory, Plymouth.
1869. ‡CUNNINGHAM, ROBERT O., M.D., F.L.S., F.G.S., Professor of Natural History in Queen's College, Belfast.
1883. *CUNNINGHAM, Rev. W., D.D., D.Sc. (Pres. F, 1891). Trinity College, Cambridge.
1892. §Cunningham-Craig, E. H., B.A., F.G.S. Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1900. *Cunnington, W. Alfred. 13 The Chase, Clapham Common, S.W.
1892. *Currie, James, jun., M.A., F.R.S.E. Larkfield, Golden Acre, Edinburgh.
1884. ‡Currier, John McNab. Newport, Vermont, U.S.A.
1902. §Curry, Professor M., M.Inst.C.E. 43 Downleaze, Sneyd Park, Bristol.

Year of Election.

1898. ‡Curtis, John. 1 Christchurch-road, Clifton, Bristol.
1878. ‡Curtis, William. Caramore, Sutton, Co. Dublin.
1884. ‡Cushing, Frank Hamilton. Washington, U.S.A.
1883. ‡Cushing, Mrs. M. Croydon, Surrey.
1881. §Cushing, Thomas, F.R.A.S. India Store Depôt, Belvedere-road, Lambeth, S.W.

1889. ‡*Dagger, John H., F.I.C. Victoria Villa, Lorne-street, Fairfield, Liverpool.*
1854. ‡Daglish, Robert. Orrell Cottage, near Wigan.
1883. ‡Dähne, F. W., Consul of the German Empire. 18 Somerset-place, Swansea.
1898. §Dalby, Professor W. E., B.Sc., M.Inst.C.E. 6 Coleridge-road, Crouch End, N.
1889. *Dale, Miss Elizabeth. 45 Oxford-road, Cambridge.
1863. ‡Dale, J. B. South Shields.
1867. ‡Dalgleish, W. Dundee.
1870. ‡DALLINGER, Rev. W. H., D.D., LL.D., F.R.S., F.L.S. Ingleside, Newstead-road, Lee, S.E.
Dalton, Edward, LL.D. Dunkirk House, Nailsworth.
1862. ‡DANBY, T. W., M.A., F.G.S. The Crouch, Seaford, Sussex.
1901. ‡Daniell, G. F., B.Sc. 44 Cavendish-road, Brondesbury, N.W.
1876. *Dansken, John, F.R.A.S. 2 Hillside-gardens, Partickhill, Glasgow.
1896. §Danson, F. C. Liverpool and London Chambers, Dale-street, Liverpool.
1849. *Danson, Joseph, F.C.S. Montreal, Canada.
1894. ‡Darbishire, B. V., M.A., F.R.G.S. 1 Savile-row, W.
1897. ‡Darbishire, C. W. Elm Lodge, Elm-row, Hampstead, N.W.
1897. §Darbishire, F. V., B.A., Ph.D. Hulme Hall, Plymouth-grove, and Owens College, Manchester.
1861. *DARBISHIRE, ROBERT DUKINFIELD, B.A. (Local Sec. 1861). Victoria Park, Manchester.
1896. ‡Darbishire, W. A. Penybryn, Carnarvon, North Wales.
1899. *Darwin, Erasmus. The Orchard, Huntingdon-road, Cambridge.
1882. ‡DARWIN, FRANCIS, M.A., M.B., F.R.S., F.L.S. (Pres. D, 1891; Council 1882–84, 1897–1901). Wychfield, Huntingdon-road, Cambridge.
1881. *DARWIN, GEORGE HOWARD, M.A., LL.D., F.R.S., F.R.A.S. (Pres. A, 1886; Council 1886–92), Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge. Newnham Grange, Cambridge.
1878. *DARWIN, HORACE. The Orchard, Huntingdon-road, Cambridge.
1894. *DARWIN, Major LEONARD, Hon. Sec. R.G.S. (Pres. E, 1896; Council 1899–). 12 Egerton-place, South Kensington, S.W.
1882. ‡Darwin, W. E., M.A., F.G.S. Bassett, Southampton.
1888. ‡Daubeny, William M. 11 St. James's-square, Bath.
1880. *DAVEY, HENRY, M.Inst.C.E., F.G.S. 3 Prince's-street, Westminster, S.W.
1898. §Davey, William John. 6 Water-street, Liverpool.
1884. ‡David, A. J., B.A., LL.B. 4 Harcourt-buildings, Temple, E.C.
1870. ‡Davidson, Alexander, M.D. 2 Gambier-terrace, Liverpool.
1902. *Davidson, S. C. Seacourt, Bangor, Co. Down.
1870. ‡Davies, Edward, F.C.S. Royal Institution, Liverpool.
1887. *Davies, H. Rees. Treborth, Bangor, North Wales.
1896. *Davies, Thomas Wilberforce, F.G.S. 41 Park-place, Cardiff.
1893. *Davies, Rev. T. Witton, B.A., Ph.D., Professor of Semitic Languages in University College, Bangor, North Wales.

Year of Election.

1898. ‡Davies, Wm. Howell, J.P. Down House, Stoke Bishop, Bristol.

1873. *Davis, Alfred. 37 Ladbroke-grove, W.

1870. *Davis, A. S. St. George's School, Roundhay, near Leeds.

1864. ‡DAVIS, CHARLES E., F.S.A. (Local Sec. 1864). 55 Pulteney-street, Bath.

1882. ‡Davis, Henry C. Berry Pomeroy, Springfield-road, Brighton.

1896. *Davis, John Henry Grant. Valindra, Wood Green, Wednesbury, Staffordshire.

1885. *Davis, Rev. Rudolf. Hopefield, Evesham.

1886. ‡Davis, W. H. Hazeldean, Pershore-road, Birmingham.

1886. ‡DAVISON, CHARLES, D.Sc. 16 Manor-road, Birmingham.

1857. ‡DAVY, E. W., M.D. Kimmage Lodge, Roundtown, Dublin.

1869. ‡Daw, John. Mount Radford, Exeter.

1869. ‡Daw, R. R. M. Bedford-circus, Exeter.

1860. *Dawes, John T. The Lilacs, Prestatyn, North Wales.

1864. ‡DAWKINS, W. BOYD, D.Sc., F.R.S., F.S.A., F.G.S. (Pres. C, 1888; Council 1882–88), Professor of Geology and Palæontology in the Victoria University, Owens College, Manchester. Woodhurst, Fallowfield, Manchester.

1886. ‡Dawson, Bernard. The Laurels, Malvern Link.

1891. ‡Dawson, Edward. 2 Windsor-place, Cardiff.

1885. **Dawson, Lieut.-Colonel H. P., R.A. Hartlington, Burnsall, Skipton.*

1901. §Dawson, P. 11 Campside-crescent, Langside, Glasgow.

1884. ‡DAWSON, SAMUEL (Local Sec. 1884). 258 University-street, Montreal, Canada.

1859. **Dawson, Captain William G. The Links, Plumstead Common, Kent.*

1892. ‡Day, T. C., F.C.S. 36 Hillside-crescent, Edinburgh.

1870. *DEACON, G. F., M.Inst.C.E. (Pres. G, 1897). 19 Warwick-square, S.W.

1900. §Deacon, M. Whittington House, near Chesterfield.

1887. ‡Deakin, H. T. Egremont House, Belmont, near Bolton.

1861. ‡Dean, Henry. Colne, Lancashire.

1901. *Deasy, Capt. H. H. P. Cavalry Club, Piccadilly, W.

1884. *Debenham, Frank, F.S.S. 1 Fitzjohn's-avenue, N.W.

1866. ‡DEBUS, HEINRICH, Ph.D., F.R.S., F.C.S. (Pres. B, 1869; Council 1870–75). 4 Schlangenweg, Cassel, Hessen.

1884. ‡Deck, Arthur, F.C.S. 9 King's-parade, Cambridge.

1893. ‡Deeley, R. M. 38 Charnwood-street, Derby.

1878. ‡Delany, Rev. William. University College, Dublin.

1896. §Dempster, John. Tynron, Noctorum, Birkenhead.

1902. §Dendy, Professor Arthur. Care of Messrs. Dulau & Co., 37 Soho-square, W.

1889. ‡*Dendy, Frederick Walter. 3 Mardale-parade, Gateshead.*

1897. ‡Denison, F. Napier. Meteorological Office, Victoria, B.C., Canada.

1896. ‡Denison, Miss Louisa E. 16 Chesham-place, S.W.

1889. §DENNY, ALFRED, F.L.S., Professor of Biology in University College, Sheffield.

Dent, William Yerbury. 5 Caithness-road, Brook Green, W.

1874. ‡DE RANCE, CHARLES E., F.G.S. 33 Carshalton-road, Blackpool.

1896. ‡DERBY, The Right Hon. the Earl of, K.G., G.C.B. (VICE-PRESIDENT, 1903). Knowsley, Prescot, Lancashire.

1874. *Derham, Walter, M.A., LL.M., F.G.S. 76 Lancaster-gate, W.

1894. *Deverell, F. H. 7 Grote's-place, Blackheath, S.E.

1899. ‡DEVONSHIRE, The Duke of, K.G., D.C.L., F.R.S. 78 Piccadilly, W.

1899. ‡Dewar, A. Redcote. Redcote, Leven, Fife.

Year of Election.

1868. *DEWAR, JAMES, M.A., LL.D., F.R.S., F.R.S.E., V.P.C.S., Fullerian Professor of Chemistry in the Royal Institution, London, and Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge (PRESIDENT; Pres. B, 1879; Council 1883–88). 1 Scroope-terrace, Cambridge.
1881. ‡Dewar, Mrs. 1 Scroope-terrace, Cambridge.
1883. ‡Dewar, James, M.D., F.R.C.S.E. Drylaw House, Davidson's Mains, Midlothian, N.B.
1884. *Dewar, William, M.A. Horton House, Rugby.
1872. ‡Dewick, Rev. E. S., M.A., F.G.S. 26 Oxford-square, W.
1884. ‡De Wolf, O. C., M.D. Chicago, U.S.A.
1873. *DEW-SMITH, A. G., M.A. Chesterton Hall, Cambridge.
1896. ‡D'Hemry, P. 136 Prince's-road, Liverpool.
1897. ‡Dick, D. B. Toronto, Canada.
1901. §Dick, George Handasyde. 31 Hamilton-drive, Hillhead, Glasgow.
1901. ‡Dick, Thomas. Lochhead House, Pollokshields, Glasgow.
1889. ‡Dickinson, A. H. The Wood, Maybury, Surrey.
1863. ‡Dickinson, G. T. Lily-avenue, Jesmond, Newcastle-upon-Tyne.
1887. ‡Dickinson, Joseph, F.G.S. South Bank, Pendleton.
1884. ‡Dickson, Charles R., M.D. Wolfe Island, Ontario, Canada.
1881. ‡Dickson, Edmund, M.A., F.G.S. 2 Starkie-street, Preston.
1887. §DICKSON, H. N., B.Sc., F.R.S.E., F.R.G.S. 2 St. Margaret's-road, Oxford.
1902. §Dickson, James D. H., M.A., F.R.S.E. 6 Cranmer-road, Cambridge.
1885. ‡Dickson, Patrick. Laurencekirk, Aberdeen.
1883. ‡*Dickson, T. A. West Cliff, Preston.*
1862. *DILKE, The Right Hon. Sir CHARLES WENTWORTH, Bart., M.P., F.R.G.S. 76 Sloane-street, S.W.
1877. ‡Dillon, James, M.Inst.C.E. 36 Dawson-street, Dublin.
1901. §Dines, W. H. Oxshott, Leatherhead.
1900. §DIVERS, Dr. EDWARD, F.R.S. (Pres. B, 1902). 9 Rugby-mansions, Kensington, W.
1898. *Dix, John William S. Hampton Lodge, Durdham Down, Clifton, Bristol.
1899 *DIXON, A. C., D.Sc., Professor of Mathematics in Queen's College, Belfast. Almora, Myrtlefield Park, Belfast.
1874. *DIXON, A. E., M.D., Professor of Chemistry in Queen's College, Cork. Mentone Villa, Sunday's Well, Cork.
1900. §Dixon, A. Francis, D.Sc., Professor of Anatomy in University College, Cardiff.
1883. ‡Dixon, Miss E. 2 Cliff-terrace, Kendal.
1888. §Dixon, Edward T. Racketts, Hythe, Hampshire.
1900. *Dixon, George, M.A. St. Bees, Cumberland.
1879. *DIXON, HAROLD B., M.A., F.R.S., F.C.S. (Pres. B, 1894), Professor of Chemistry in the Owens College, Manchester.
1902. §Dixon, Henry H., D.Sc. 23 Northbrook-road, Dublin.
1885. ‡Dixon, John Henry. Inveran, Poolewe, Ross-shire, N.B.
1896. §Dixon-Nuttall, F. R. Ingleholme, Eccleston Park, Prescot.
1887. ‡Dixon, Thomas. Buttershaw, near Bradford, Yorkshire.
1902. §Dixon, W. V. Scotch Quarter, Carrickfergus.
1885. ‡Doak, Rev. A. 15 Queen's-road, Aberdeen.
1890. ‡Dobbie, James J., D.Sc. Professor of Chemistry, University College, Bangor, North Wales.
1885. §Dobbin, Leonard, Ph.D. The University, Edinburgh.
1860. *Dobbs, Archibald Edward, M.A. Hartley Manor, Longfield, Kent.
1902. §Dobbs, F. W. 2 Willowbrook, Eton, Windsor.

Year of Election.

1897. ‡Doberck, William. The Observatory, Hong Kong.
1892. ‡Dobie, W. Fraser. 47 Grange-road, Edinburgh.
1891. ‡Dobson, G. Alkali and Ammonia Works, Cardiff.
1893. ‡Dobson, W. E., J.P. Lenton-road, The Park, Nottingham.
1875. *Docwra, George. Cinderford, R.S.O., Gloucestershire.
1870. *Dodd, John. Nunthorpe-avenue, York.
1876. ‡Dodds, J. M. St. Peter's College, Cambridge.
1897. ‡Dodge, Richard E. Teachers' College, Columbia University, New York, U.S.A.
1889. ‡Dodson, George, B.A. Downing College, Cambridge.
1898. ‡Dole, James. Redland House, Bristol.
1893. ‡Donald, Charles W. Kinsgarth, Braid-road, Edinburgh.
1885. †Donaldson, James, M.A., LL.D., F.R.S.E., Senior Principal of the University of St. Andrews, N.B.
1889. ‡Donkin, R. S., M.P. Campville, North Shields.
1896. ‡Donnan, F. E. Ardenmore-terrace, Holywood, Ireland.
1901. §Donnan, F. G. University College, Gower Street, W.C.
1881. ‡Dorrington, John Edward. Lypiatt Park, Stroud.
1867. ‡Dougall, Andrew Maitland, R.N. Scotscraig, Tayport, Fifeshire.
1863. *Doughty, Charles Montagu. Illawara House, Tunbridge Wells.
1884. ‡Douglass, William Alexander. Freehold Loan and Savings Company, Church-street, Toronto, Canada.
1890. ‡Dovaston, John. West Felton, Oswestry.
1883. ‡Dove, Arthur. Crown Cottage, York.
1884. ‡Dove, Miss Frances. St. Leonard's, St. Andrews, N.B.
1876. ‡Dowie, Mrs. Muir. Golland, by Kinross, N.B.
1884. *Dowling, D. J. Bromley, Kent.
1865. *Dowson, E. Theodore, F.R.M.S. Geldeston, near Beccles, Suffolk.
1881. *Dowson, J. Emerson, M.Inst.C.E. 91 Cheyne-walk, S.W.
1887. ‡Doxey, R. A. Slade House, Levenshulme, Manchester.
1894. ‡Doyne, R. W., F.R.C.S. 28 Beaumont-street, Oxford.
1883. ‡Draper, William. De Grey House, St. Leonard's, York.
1892. *Dreghorn, David, J.P. 188 Nethersdale-drive, Pollokshields, Glasgow.
1868. ‡DRESSER, HENRY E., F.Z.S. 110 Cannon-street, E.C.
1890. ‡Drew, John. 12 Harringay-park, Crouch End, Middlesex, N.
1892. ‡Dreyer, John L. E., M.A., Ph.D., F.R.A.S. The Observatory, Armagh.
1893. §DRUCE, G. CLARIDGE, M.A., F.L.S. (Local Sec. 1894). 118 High-street, Oxford.
1889. ‡Drummond, Dr. 6 Saville-place, Newcastle-upon-Tyne.
1897. ‡Drynan, Miss. Northwold, Queen's Park, Toronto, Canada.
1901. ‡Drysdale, John W. W. Bon Accord Engine Works, London-road, Glasgow.
1892. ‡Du Bois, Dr. H. Mittelstrasse, 39, Berlin.
1856. *DUCIE, The Right. Hon. HENRY JOHN REYNOLDS MORETON, Earl of, F.R.S., F.G.S. 16 Portman-square, W.; and Tortworth Court, Falfield, Gloucestershire.
1870. ‡Duckworth, Henry, F.L.S., F.G.S. Christchurch Vicarage, Chester.
1900. *Duckworth, W. L. H. Jesus College, Cambridge.
1895. *Duddell, William. 47 Hans-place, S.W.
1867. *DUFF, The Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT-, G.C.S.I., F.R.S., F.R.G.S. (Pres. F, 1867, 1881; Council 1868, 1892–93). 11 Chelsea-embankment, S.W.
1877. ‡Duffey, George F., M.D. 30 Fitzwilliam-place, Dublin.
1875. ‡Duffin, W. E. L'Estrange. Waterford.
1890. ‡Dufton, S. F. Trinity College, Cambridge.

Year of Election.
1884. ‡Dugdale, James H. 9 Hyde Park-gardens, W.
1883. ‡Duke, Frederic. Conservative Club, Hastings.
1892. ‡Dulier, Colonel E., C.B. 27 Sloane-gardens, S.W.
1866. *Duncan, James. 9 Mincing-lane, E.C.
1891. *Duncan, John, J.P. 'South Wales Daily News' Office, Cardiff.
1896. ‡Duncanson, Thomas. 16 Deane-road, Liverpool.
1893. *Dunell, George Robert. 33 Spencer-road, Grove Park, Chiswick, W.
1892. ‡Dunham, Miss Helen Bliss. Messrs. Morton, Rose, & Co., Bartholomew House, E.C.
1896. *DUNKERLEY, S., M.Sc., Professor of Applied Mechanics in the Royal Naval College, Greenwich, S.E.
1865. ‡Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.
1882. ‡*Dunn, J. T., M.Sc., F.C.S. Northern Polytechnic Institute, Holloway, N.*
1883. ‡*Dunn, Mrs. J. T. Northern Polytechnic Institute, Holloway, N.*
1876. ‡Dunnachie, James. 2 West Regent-street, Glasgow.
1884. §Dunnington, Professor F. P. University of Virginia, Charlottesville, Virginia, U.S.A.
1859. ‡Duns, Rev. John, D.D., F.R.S.E. New College, Edinburgh.
1893. *Dunstan, M. J. R., Principal of the South-Eastern Agricultural College, Wye, Kent.
1891. ‡Dunstan, Mrs. South-Eastern Agricultural College, Wye, Kent.
1885. *DUNSTAN, WYNDHAM R., M.A., F.R.S., Sec.C.S., Director of the Imperial Institute, S.W.
1869. ‡D'Urban, W. S. M. Newport House, near Exeter.
1898. ‡Durrant, R. G. Marlborough College, Wilts.
1895. *DWERRYHOUSE, ARTHUR R., M.Sc., F.G.S. 5 Oakfield-terrace, Headingley, Leeds.
1887. ‡*Dyason, John Sanford. Cuthbert-street, W.*
1884. ‡Dyck, Professor Walter. The University, Munich.
1885. *Dyer, Henry, M.A., D.Sc. 8 Highburgh-terrace, Dowanhill, Glasgow.
1869. *Dymond, Edward E. Oaklands, Aspley Guise, Bletchley.
1895. §Dymond, Thomas S., F.C.S. County Technical Laboratory, Chelmsford, Essex.

1868. ‡Eade, Sir Peter, M.D. Upper St. Giles's-street, Norwich.
1895. ‡*Earle, Hardman A. 29 Queen Anne's-gate, Westminster, S.W.*
1877. ‡Earle, Ven. Archdeacon, M.A. West Alvington, Devon.
1874. ‡Eason, Charles. 30 Kenilworth-square, Rathgar, Dublin.
1899. §East, W. H. Municipal School of Art, Science, and Technology, Dover.
1871. *EASTON, EDWARD (Pres. G, 1878; Council 1879–81). 11 Delahay-street, Westminster, S.W.
1863. ‡Easton, James. Nest House, near Gateshead, Durham.
1876. ‡Easton, John. Durie House, Abercromby-street, Helensburgh, N.B.
1883. ‡Eastwood, Miss. Littleover Grange, Derby.
1893. *Ebbs, Alfred B. Northumberland-alley, Fenchurch-street, E.C.
1884. ‡Eckersley, W. T. Standish Hall, Wigan, Lancashire.
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
1870. *Eddison, John Edwin, M.D., M.R.C.S. The Lodge, Adel, Leeds.
1899. ‡Eddowes, Alfred, M.D. 28 Wimpole-street, W.
*Eddy, James Ray, F.G.S. The Grange, Carleton, Skipton.
1887. ‡Ede, Francis J., F.G.S. Silchar, Cachar, India.
1884. *Edgell, Rev. R. Arnold, M.A., F.C.S. The College House, Leamington.

Year of Election.

1887. §EDGEWORTH, F. Y., M.A., D.C.L., F.S.S. (Pres. F, 1889; Council 1879–86, 1891–98), Professor of Political Economy in the University of Oxford. All Souls College, Oxford.
1870. *Edmonds, F. B. 6 Clement's Inn, W.C.
1883. §Edmonds, William. Wiscombe Park, Colyton, Devon.
1888. *Edmunds, Henry. Antron, 71 Upper Tulse-hill, S.W.
1884. *Edmunds, James, M.D. 4 Chichester-terrace, Kemp Town, Brighton.
1883. ‡Edmunds, Lewis, D.Sc., LL.M., F.G.S. 1 Garden-court, Temple, E.C.
1899. §Edwards, E. J., Assoc.M.Inst.C.E. 2 Dafforne-road, Upper Tooting, S.W.
1884. ‡Edwards, W. F. Niles, Michigan, U.S.A.
1887. *Egerton of Tatton, The Right Hon. Lord. Tatton Park, Knutsford.
1901. §Eggar, W. D. Eton College, Windsor.
1896. ‡Ekkert, Miss Dorothea. 95 Upper Parliament-street, Liverpool.
1876. ‡Elder, Mrs. 6 Claremont-terrace, Glasgow.
1890. §Elford, Percy. St. John's College, Oxford.
1885. *ELGAR, FRANCIS, LL.D., F.R.S., F.R.S.E., M.Inst.C.E. 34 Leadenhall-street, E.C.
1901. *Elles, Miss Gertrude L. Newnham College, Cambridge.
1883. ‡Ellington, Edward Bayzand, M.Inst.C.E. Palace-chambers, Bridge-street, Westminster, S.W.
1891. ‡Elliott, A. C., D.Sc., Professor of Engineering in University College, Cardiff. 2 Plasturton-avenue, Cardiff.
1883. *ELLIOTT, EDWIN BAILEY, M.A., F.R.S., F.R.A.S., Waynflete Professor of Pure Mathematics in the University of Oxford. 4 Bardwell-road, Oxford.
Elliott, John Fogg. Elvet Hill, Durham.
1886. ‡ELLIOT, Sir THOMAS HENRY, K.C.B., F.S.S. Board of Agriculture, 4 Whitehall-place, S.W.
1875. *Ellis, H. D. 12 Gloucester-terrace, Hyde Park, W.
1880. *ELLIS, JOHN HENRY (Local Sec. 1883). Woodhaye, Ivy Bridge, Devon.
1891. §Ellis, Miss M. A. 11 Canterbury-road, Oxford.
1884. ‡Ellis, Professor W. Hodgson, M.A., M.B. 74 St. Alban's-street, Toronto, Canada.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1887. ‡Elmy, Ben. Congleton, Cheshire.
1862. ‡Elphinstone, Sir H. W., Bart., M.A., F.L.S. 2 Stone-buildings, Lincoln's Inn, W.C.
1899. *Elvery, Miss Amelia. The Cedars, Maison Dieu-road, Dover.
1897. §Elvery, Mrs. Elizabeth. The Cedars, Maison Dieu-road, Dover.
1883. ‡Elwes, Captain George Robert. Bossington, Bournemouth.
1887. §ELWORTHY, FREDERICK T., F.S.A. Foxdown, Wellington, Somerset.
1870. *ELY, The Right Rev. Lord ALWYNE COMPTON, D.D., Lord Bishop of. The Palace, Ely, Cambridgeshire.
1897. ‡Ely, Robert E. 23 West 44th-street, New York, U.S.A.
1891. ‡Emerton, Wolseley, D.C.L. Banwell Castle, Somerset.
1884. ‡Emery, Albert H. Stamford, Connecticut, U.S.A.
1863. ‡Emery, The Ven. Archdeacon, B.D. Ely, Cambridgeshire.
1894. ‡Emtage, W. T. A., Director of Public Instruction, Mauritius.
1866. ‡Enfield, Richard. Low Pavement, Nottingham.
1884. ‡England, Luther M. Knowlton, Quebec, Canada.
1853. ‡English, E. Wilkins. Yorkshire Banking Company, Lowgate, Hull.
1883. ‡Entwistle, James P. Beachfield, 2 Westclyffe-road, Southport.
1869. *Enys, John Davis. Enys, Penryn, Cornwall.

Year of Election.

1894. §Erskine-Murray, James. University College, Nottingham.
1862. *ESSON, WILLIAM, M.A., F.R.S., F.R.A.S., Savilian Professor of Geometry in the University of Oxford. 13 Bradmore-road, Oxford.
1887. *Estcourt, Charles. Hayesleigh, Montague-road, Old Trafford, Manchester.
1887. *Estcourt, P. A., F.C.S., F.I.C. Seymour House, Seymour-street, Manchester.
1869. ‡ETHERIDGE, R., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1882). 14 Carlyle-square, S.W.
1888. ‡Etheridge, Mrs. 14 Carlyle-square, S.W.
1901. ‡Ettersbank, John. Care of Messrs. Dalgety & Co., 52 Lombard-street, E.C.
1883. ‡Eunson, Henry J., Assoc.M.Inst.C.E. Vizianagram, Madras.
1889. *EVANS, A. H., M.A. 9 Harvey-road, Cambridge.
1870. *EVANS, ARTHUR JOHN, M.A., F.R.S., F.S.A. (Pres. H, 1896). Youlbury, Abingdon.
1865. *EVANS, Rev. CHARLES, M.A. Parkstone, Dorset.
1896. ‡Evans, Edward, jun. Spital Old Hall, Bromborough, Cheshire
1891. ‡Evans, Franklen. Llwynarthen, Castleton, Cardiff.
1889. ‡Evans, Henry Jones. Greenhill, Whitchurch, Cardiff.
1887. *Evans, Mrs. Isabel. Hoghton Hall, Hoghton, near Preston.
1883. *Evans, James C. 38 Crescent-road, Birkdale, Southport.
1883. *Evans, Mrs. James C. 38 Crescent-road, Birkdale, Southport.
1861. *EVANS, Sir JOHN, K.C.B., D.C.L., LL.D., D.Sc., F.R.S., F.S.A., F.L.S., F.G.S. (PRESIDENT, 1897; Pres. C, 1878; Pres. H, 1890; Council 1868–74, 1875–82, 1889–96). Nash Mills, Hemel Hempstead.
1897. *Evans, Lady. Nash Mills, Hemel Hempstead.
1898. ‡Evans, Jonathan L. 4 Litfield-place, Clifton, Bristol.
1881. ‡Evans, Lewis. Llanfyrnach, R.S.O., Pembrokeshire.
1885. *Evans, Percy Bagnall. The Spring, Kenilworth.
1865. ‡EVANS, SEBASTIAN, M.A., LL.D. Canterbury.
1899. ‡Evans, Mrs. Canterbury.
1865. *Evans, William. The Spring, Kenilworth.
1891. ‡*Evan-Thomas, C., J.P. The Gnoll, Neath, Glamorganshire.*
1886. ‡Eve, A. S. Marlborough College, Wilts.
1871. ‡Eve, H. Weston, M.A. 37 Gordon-square, W.C.
1868. *EVERETT, J. D., M.A., D.C.L., F.R.S., F.R.S.E. 11 Leopold-road, Ealing, W.
1902. *Everett, Percy W. Oaklands, Elstree, Hertfordshire.
1895. ‡Everett, W. H., B.A. University College, Nottingham.
1863. *Everitt, George Allen, F.R.G.S. Knowle Hall, Warwickshire.
1886. ‡Everitt, William E. Finstall Park, Bromsgrove.
1883. ‡Eves, Miss Florence. Uxbridge.
1881. ‡EWART, J. COSSAR, M.D., F.R.S. (Pres. D, 1901), Professor of Natural History in the University of Edinburgh.
1874. ‡EWART, Sir W. QUARTUS, Bart. (Local Sec. 1874). Glenmachan, Belfast.
1876. *EWING, JAMES ALFRED, M.A., B.Sc., F.R.S., F.R.S.E., M.Inst. C.E., Professor of Mechanism and Applied Mechanics in the University of Cambridge. Langdale Lodge, Cambridge.
1883. ‡Ewing, James L. 52 North Bridge, Edinburgh.
1884. *Eyerman, John, F.Z.S. Oakhurst, Easton, Pennsylvania, U.S.A.
1882. ‡Eyre, G. E. Briscoe. Warrens, near Lyndhurst, Hants.
Eyton, Charles. Hendred House, Abingdon.

Year of Election.

1890. ‡FABER, EDMUND BECKETT. Straylea, Harrogate.
1896. ‡Fairbrother, Thomas. 46 Lethbridge-road, Southport.
1901. §Fairgrieve, M. McCallum. New College, Eastbourne.
1865. *FAIRLEY, THOMAS, F.R.S.E., F.C.S. 8 Newton-grove, Leeds.
1896. §Falk, Herman John, M.A. Thorshill, West Kirby, Liverpool.
1902. §Fallaize, E. N., M.A. Anthropological Institute, 3 Hanover-square, W.
1898. §Faraday, Miss Ethel R., M.A. Ramsay Lodge, Levenshulme, near Manchester.
1877. §FARADAY, F. J., F.L.S., F.S.S. (Local Sec. 1887). College-chambers, 17 Brazennose-street, Manchester.
1891. ‡*Fards, G. Penarth.*
1902. §Faren, William. 11 Mount Charles, Belfast.
1892. *FARMER, J. BRETLAND, M.A., F.R.S., F.L.S., Professor of Botany, Royal College of Science, Exhibition-road, S.W.
1886. ‡Farncombe, Joseph, J.P. Saltwood, Spencer-road, Eastbourne.
1897. *Farnworth, Ernest. Broadlands, Goldthorn Hill, Wolverhampton.
1897. *Farnworth, Mrs. Ernest. Broadlands, Goldthorn Hill, Wolverhampton.
1883. ‡Farnworth, Walter. 86 Preston New-road, Blackburn.
1883. ‡Farnworth, William. 86 Preston New-road, Blackburn.
1885. ‡Farquhar, Admiral. Carlogie, Aberdeen.
1886. ‡FARQUHARSON, Colonel Sir J., K.C.B., R.E. Corrachee, Tarland, Aberdeen.
1859. ‡Farquharson, Robert F. O. Annisland, Kincardine O'Neil, N.B.
1885. *Farquharson, Mrs. R. F. O. Annisland, Kincardine O'Neil, N.B.
1866. *FARRAR, The Very Rev. FREDERIC WILLIAM, D.D., F.R.S. The Deanery, Canterbury.
1883. ‡Farrell, John Arthur. Moynalty, Kells, North Ireland.
1897. ‡Farthing, Rev. J. C., M.A. The Rectory, Woodstock, Ontario, Canada.
1869. *Faulding, Joseph. Boxley House, Tenterden, Kent.
1883. ‡Faulding, Mrs. Boxley House, Tenterden, Kent.
1887. §Faulkner, John. 13 Great Ducie-street, Strangeways, Manchester.
1890. *Fawcett, F. B. University College, Bristol.
1900. ‡FAWCETT, J. E., J.P. (Local Sec. 1900). Low Royd, Apperley Bridge, Bradford.
1902. *Fawsitt, C. E., Ph.D. 9 Foremount-terrace, Dowanhill, Glasgow.
1901. *Fearnsides, W. G., B.A., F.G.S. Addingford Hill, Horbury, Yorkshire.
1886. ‡Felkin, Robert W., M.D., F.R.G.S. 48 Westbourne-gardens, Bayswater, W.
1900. *Fennell, W. John. Kilcoroon, Stockman's-lane, Belfast.
1883. ‡Fenwick, E. H. 29 Harley-street, W.
1890. ‡Fenwick, T. Chapel Allerton, Leeds.
1876. ‡Ferguson, Alexander A. 11 Grosvenor-terrace, Glasgow.
1883. ‡Ferguson, Mrs. A. A. 11 Grosvenor-terrace, Glasgow.
1902. §FERGUSON, GODFREY W. (Local Sec. 1902). Cluan, Donegall Park, Belfast.
1871. *FERGUSON, JOHN, M.A., LL.D., F.R.S.E., F.S.A., F.C.S., Professor of Chemistry in the University of Glasgow.
1896. *Ferguson, John. Colombo, Ceylon.
1867. ‡Ferguson, Robert M., LL.D., Ph.D., F.R.S.E. 5 Learmonth-terrace, Edinburgh.
1901. §Ferguson, R. W. 8 Havelock-terrace, Paisley-road, Glasgow.
1883. ‡Fernald, H. P. Clarence House, Promenade, Cheltenham.
1883. *Fernie, John. Box No. 2, Hutchinson, Kansas, U.S.A.
1873. ‡FERRIER, DAVID, M.A., M.D., LL.D., F.R.S., Professor of Neuro-Pathology in King's College, London. 34 Cavendish-square, W.

Year of Election.

1892. ‡Ferrier, Robert M., B.Sc., Professor of Engineering, University College, Bristol.

1897. ‡Ferrier, W. F. Geological Survey, Ottawa, Canada.

1897. ‡Fessenden, Reginald A., Professor of Electrical Engineering, University, Alleghany, Pennsylvania, U.S.A.

1882. §Fewings, James, B.A., B.Sc. King Edward VI. Grammar School, Southampton.

1887. ‡Fiddes, Thomas, M.D. Penwood, Urmston, near Manchester.

1875. ‡Fiddes, Walter. Clapton Villa, Tyndall's Park, Clifton, Bristol.

1868. ‡Field, Edward. Norwich.

1897. ‡Field, George Wilton, Ph.D. Experimental Station, Kingston, Rhode Island, U.S.A.

1886. ‡*Field, H. C. 4 Carpenter-road, Edgbaston, Birmingham.*

1882. ‡Filliter, Freeland. St. Martin's House, Wareham, Dorset.

1883. *Finch, Gerard B., M.A. 1 St. Peter's-terrace, Cambridge.

1878. *Findlater, Sir William. 22 Fitzwilliam-square, Dublin.

1884. ‡Finlay, Samuel. Montreal, Canada.

1902. §Finnegan, J., B.A., B.Sc. Kelvin House, Botanic-avenue, Belfast.

1887. ‡Finnemore, Rev. J., M.A., Ph.D., F.G.S. 88 Upper Hanover-street, Sheffield.

1881. ‡Firth, Colonel Sir Charles. Heckmondwike.

1895. §Fish, Frederick J. Spursholt, Park-road, Ipswich.

1891. ‡Fisher, Major H. O. The Highlands, Llandough, near Cardiff.

1902. §Fisher, J. R. Cranfield, Fortwilliam Park, Belfast.

1884. *Fisher, L. C. Galveston, Texas, U.S.A.

1869. ‡FISHER, Rev. OSMOND, M.A., F.G.S. Harlton Rectory, near Cambridge.

1875. *Fisher, W. W., M.A., F.C.S. 5 St. Margaret's-road, Oxford.

1858. ‡Fishwick, Henry. Carr-hill, Rochdale.

1887. *Fison, Alfred H., D.Sc. 25 Blenheim-gardens, Willesden Green, N.W.

1885. ‡Fison, E. Herbert. Stoke House, Ipswich.

1871. *FISON, FREDERICK W., M.A., M.P., F.C.S. Greenholme, Burley-in-Wharfedale, near Leeds.

1871. ‡FITCH, Sir J. G., M.A., LL.D. (Council, 1871–75). Athenæum Club, S.W.

1883. ‡Fitch, Rev. J. J. 5 Chambres-road, Southport.

1878. ‡Fitzgerald, C. E., M.D. 27 Upper Merrion-street, Dublin.

1885. *FITZGERALD, Professor MAURICE, B.A. (Local Sec. 1902). 32 Eglantine-avenue, Belfast.

1894. ‡Fitzmaurice, M., C.M.G., M.Inst.C.E. London County Council, Spring-gardens, S.W.

1888. *FITZPATRICK, Rev. THOMAS C. Christ's College, Cambridge.

1897. ‡Flavelle, J. W. 565 Jarvis-street, Toronto, Canada.

1881. ‡Fleming, Rev. Canon J., B.D. St. Michael's Vicarage, Ebury-square, S.W.

1876. ‡Fleming, James Brown. Beaconsfield, Kelvinside, Glasgow.

1876. ‡Fleming, Sir Sandford, K.C.M.G., F.G.S. Ottawa, Canada.

1867. ‡FLETCHER, ALFRED E., F.C.S. Delmore, Caterham, Surrey.

1870. ‡Fletcher, B. Edgington. Marlingford Hall, Norwich.

1890. ‡Fletcher, B. Morley. 7 Victoria-street, S.W.

1892. ‡Fletcher, George, F.G.S. Cumberland Lodge, Moseley, Birmingham.

1888. *FLETCHER, LAZARUS, M.A., F.R.S., F.G.S., F.C.S. (Pres. C, 1894), Keeper of Minerals, British Museum (Natural History), Cromwell-road, S.W. 35 Woodville-gardens, Ealing, W.

1901. ‡Flett, J. S., M.A., D.Sc. 28 Jermyn-street, S.W.

1889. ‡Flower, Lady. 26 Stanhope-gardens, S.W.

1877. *Floyer, Ernest A. Camberley, Surrey.

Year of Election.

1890. *FLUX, A. W., M.A., Professor of Political Economy in the University, Montreal.
1891. ‡Foldvary, William. Museum Ring, 10, Buda Pesth.
1880. ‡Foote, R. Bruce, F.G.S. Care of Messrs. H. S. King & Co., 65 Cornhill, E.C.
1873. *FORBES, GEORGE, M.A., F.R.S., F.R.S.E., M.Inst.C.E. 34 Great George-street, S.W.
1883. ‡FORBES, HENRY O., LL.D., F.Z.S., Director of Museums for the Corporation of Liverpool. The Museum, Liverpool.
1897. ‡Forbes, J., K.C. Hazeldean, Putney-hill, S.W.
1885. ‡Forbes, The Right Hon. Lord. Castle Forbes, Aberdeenshire.
1890. ‡FORD, J. RAWLINSON (Local Sec. 1890). Quarry Dene, Weetwood-lane, Leeds.
1875. *FORDHAM, H. GEORGE. Odsey, Ashwell, Baldock, Herts.
1894. ‡*Forrest, Frederick. Beechwood, Castle Hill, Hastings.*
1887. ‡FORREST, The Right Hon. Sir JOHN, G.C.M.G., F.R.G.S., F.G.S. Perth, Western Australia.
1902. §Forster, M. O., Ph.D. Royal College of Science, S.W.
1883. ‡FORSYTH, A. R., M.A., D.Sc., F.R.S. (Pres. A, 1897), Sadlerian Professor of Pure Mathematics in the University of Cambridge. Trinity College, Cambridge.
1900. ‡Forsyth, D. Central Higher Grade School, Leeds.
1884. ‡Fort, George H. Lakefield, Ontario, Canada.
1877. ‡FORTESCUE, The Right Hon. the Earl. Castle Hill, North Devon.
1896. ‡FORWOOD, Sir WILLIAM B., J.P. Ramleh, Blundellsands, Liverpool.
1875. ‡Foster, A. Le Neve. 51 Cadogan-square, S.W.
1865. ‡Foster, Sir B. Walter, M.D., M.P. 16 Temple-row, Birmingham.
1865. *FOSTER, CLEMENT LE NEVE, B.A., D.Sc., F.R.S., F.G.S., Professor of Mining in the Royal College of Science, London.
1883. ‡Foster, Mrs. C. Le Neve.
1857. *FOSTER, GEORGE CAREY, B.A., LL.D., D.Sc., F.R.S. (GENERAL TREASURER, 1898– ; Pres, A, 1877; Council 1871-76, 1877-82). Ladywalk, Rickmansworth.
1896. ‡Foster, Miss Harriet. Cambridge Training College, Wollaston-road, Cambridge.
1859. *FOSTER, Sir MICHAEL, K.C.B., M.P., M.A., M.D., LL.D., D.C.L., Sec.R.S., F.L.S. (PRESIDENT, 1899; GEN. SEC. 1872–76; Pres. I, 1897; Council, 1871–72), Professor of Physiology in the University of Cambridge. Great Shelford, Cambridge.
1901. §Foster, T. Gregory, Ph.D. University College, W.C.; and Clifton, Northwood, Middlesex.
1896. ‡Fowkes, F. Hawkshead, Ambleside.
1866. ‡Fowler, George, M.Inst.C.E., F.G.S. Basford Hall, near Nottingham.
1868. ‡Fowler, G. G. Gunton Hall, Lowestoft, Suffolk.
1892. ‡Fowler, Miss Jessie A. 4 & 5 Imperial-buildings, Ludgate-circus, E.C.
1901. ‡Fowlis, William. 45 John-street, Glasgow.
1883. *Fox, Charles. The Chestnuts, Warlingham-on-the-Hill, Surrey.
1883. §Fox, Sir CHARLES DOUGLAS, M.Inst.C.E. (Pres. G, 1896). 28 Victoria-street, Westminster, S.W.
1896. ‡Fox, Henry J. Bank's Dale, Bromborough, near Liverpool.
1883. ‡Fox, Howard, F.G.S. Rosehill, Falmouth.
1847. *Fox, Joseph Hoyland. The Clive, Wellington, Somerset.
1900. *Fox, Thomas. Pyles Thorne House, Wellington, Somerset.
1881. *FOXWELL, HERBERT S., M.A., F.S.S. (Council 1894–97), Professor of Political Economy in University College, London. St. John's College, Cambridge.

Year of Election.

1889. ‡Frain, Joseph, M.D. Grosvenor-place, Jesmond, Newcastle-upon-Tyne.

FRANCIS, WILLIAM, Ph.D., F.L.S., F.G.S., F.R.A.S. Red Lion-court, Fleet-street, E.C.: and Manor House, Richmond, Surrey.

1887. *FRANKLAND, PERCY F., Ph.D., B.Sc., F.R.S. (Pres. B, 1901), Professor of Chemistry in the University of Birmingham.

1894. ‡Franklin, Mrs. E. L. 50 Porchester-terrace, W.

1895. §Fraser, Alexander. 63 Church-street, Inverness.

1882. *Fraser, Alexander, M.B., Professor of Anatomy in the Royal College of Surgeons, Dublin.

1885. ‡FRASER, ANGUS, M.A., M.D., F.C.S. (Local Sec. 1885). 232 Union-street, Aberdeen.

1865. *FRASER, JOHN, M.A., M.D., F.G.S. Chapel Ash, Wolverhampton.

1871. ‡FRASER, Sir THOMAS R., M.D., F.R.S., F.R.S.E., Professor of Materia Medica and Clinical Medicine in the University of Edinburgh. 13 Drumsheugh-gardens, Edinburgh.

1871. ‡Frazer, Evan L. R. Brunswick-terrace, Spring Bank, Hull.

1884. *Frazer, Persifor, M.A., D.Sc. (Univ. de France). Room 1042, Drexel Building, Philadelphia, U.S.A.

1884. *FREAM, W., LL.D., B.Sc., F.L.S., F.G.S., F.S.S. The Vinery, Downton, Salisbury.

1877. §Freeman, Francis Ford. Abbotsfield, Tavistock, South Devon

1884. *FREMANTLE, The Hon. Sir C. W., K.C.B. (Pres. F, 1892; Council 1897–). 4 Lower Sloane-street, S.W.

1886. ‡FRESHFIELD, DOUGLAS W., F.R.G.S. 1 Airlie-gardens, Campden Hill, W.

1901. §Frew, William, Ph.D. 11 Hillhead-street, Glasgow.

1887. ‡Fries, Harold H., Ph.D. 92 Reade-street, New York, U.S.A.

1887. ‡*Froehlich, The Cavaliere. Grosvenor-terrace, Withington, Manchester.*

1892. *Frost, Edmund, M.B. Chesterfield, Meads, Eastbourne.

1882. §Frost, Edward P., J.P. West Wratting Hall, Cambridgeshire.

1887. *Frost, Robert, B.Sc. 53 Victoria-road, W.

1899. ‡Fry, Edward W. Cannon-street, Dover.

1898. ‡FRY, The Right Hon. Sir EDWARD, D.C.L., LL.D., F.R.S., F.S.A. Failand House, Failand, near Bristol.

1898 ‡Fry, Francis J. Leigh Woods, Clifton, Bristol.

1875. *Fry, Joseph Storrs. 17 Upper Belgrave-road, Clifton, Bristol.

1898. ‡Fryer, Alfred C., Ph.D. 13 Eaton-crescent, Clifton, Bristol.

1884. ‡Fryer, Joseph, J.P. Smelt House, Howden-le-Wear, Co. Durham.

1895. ‡FULLARTON, Dr. J. H. Fishery Board for Scotland, George-street, Edinburgh.

1872. *Fuller, Rev. A. 7 Sydenham-hill, Sydenham, S.E.

1859. ‡FULLER, FREDERICK, M.A. (Local Sec. 1859). 9 Palace-road, Surbiton.

1869. ‡FULLER, G., M.Inst.C.E. (Local Sec. 1874). 71 Lexham-gardens, Kensington, W.

1884. ‡Fuller, William, M.B. Oswestry.

1891. ‡*Fulton, Andrew. 23 Park-place, Cardiff.*

1887. ‡Gaddum, G. H. Adria House, Toy-lane, Withington, Manchester.

1863. *Gainsford, W. D. Skendleby Hall, Spilsby.

1896. ‡Gair, H. W. 21 Water-street, Liverpool.

1850. ‡GAIRDNER, Sir W. T., K.C.B., M.D., LL.D., F.R.S. 32 George-square, Edinburgh.

1876. ‡Gale, James M. 23 Miller-street, Glasgow.

1885 *Gallaway, Alexander. Dirgarve, Aberfeldy, N.B.

Year of Election.

1861. ‡Galloway, Charles John. Knott Mill Iron Works, Manchester.

1889. ‡Galloway, Walter. Eighton Banks, Gateshead.

1875. ‡GALLOWAY, W. Cardiff.

1887. *Galloway, W. J., M.P. The Cottage, Seymour-grove, Old Trafford, Manchester.

1899. §Galton, Lady Douglas. Himbleton Manor, Droitwich.

1860. *GALTON, FRANCIS, M.A., D.C.L., D.Sc., F.R.S., F.R.G.S. (GEN. SEC. 1863–68; Pres. E, 1862, 1872; Pres. H, 1885; Council 1860–63). 42 Rutland-gate, Knightsbridge, S.W.

1869. ‡GALTON, JOHN C., M.A., F.L.S. New University Club, St. James's-street, S.W.

1870. §Gamble, Lieut.-Colonel Sir D., Bart., C.B. St. Helens, Lancashire.

1889. ‡Gamble, David. Ratonagh, Colwyn Bay.

1870. ‡Gamble, J. C. St. Helens, Lancashire.

1888. *GAMBLE, J. SYKES, C.I.E., M.A., F.R.S., F.L.S. Highfield, East Liss, Hants.

1877. ‡Gamble, William. St. Helens, Lancashire.

1868. ‡GAMGEE, ARTHUR, M.D., F.R.S. (Pres. D, 1882; Council 1888–90). 5 Avenue du Kursaal, Montreux, Switzerland.

1899. *Garcke, E. Ditton House, near Maidenhead.

1898. §Garde, Rev. C. L. Skenfrith Vicarage, near Monmouth.

1900. §Gardiner, J. Stanley, M.A. Dunstall, Newton-road, Cambridge.

1887. ‡GARDINER, WALTER, M.A., F.R.S. 45 Hills-road, Cambridge.

1882. *Gardner, H. Dent, F.R.G.S. Fairmead, 46 The Goffs, Eastbourne.

1896. ‡Gardner, James. The Groves, Grassendale, Liverpool.

1894. ‡*Gardner, J. Addyman. 5 Bath-place, Oxford.*

1882. ‡GARDNER, JOHN STARKIE. 29 Albert Embankment, S.E.

1884. ‡Garman, Samuel. Cambridge, Massachusetts, U.S.A.

1887. *Garnett, Jeremiah. The Grange, Bromley Cross, near Bolton, Lancashire.

1882. ‡Garnett, William, D.C.L. London County Council, Spring-gardens, S.W.

1873. ‡Garnham, John. Hazelwood, Crescent-road, St. John's, Brockley, Kent, S.E.

1883. ‡GARSON, J. G., M.D. (ASSISTANT GENERAL SECRETARY.) 14 Stratford-place, W.

1894. *GARSTANG, WALTER, M.A., F.Z.S. Marine Biological Laboratory, Plymouth.

1874. *Garstin, John Ribton, M.A., LL.B., M.R.I.A., F.S.A. Bragans-town, Castlebellingham, Ireland.

1882. ‡Garton, William. Woolston, Southampton.

1892. ‡Garvie, James. Bolton's Park, Potter's Bar.

1889. ‡GARWOOD, Professor E. J., M.A., F.G.S. University College, Gower-street, W.C.

1870. ‡Gaskell, Holbrook. Woolton Wood, Liverpool.

1870. *Gaskell, Holbrook, jun. Bridge House, Sefton Park, Liverpool.

1896. *GASKELL, WALTER HOLBROOK, M.A., M.D., LL.D., F.R.S. (Pres. I, 1896; Council 1898–1901). The Uplands, Great Shelford, near Cambridge.

1896. ‡Gatehouse, Charles. Westwood, Noctorum, Birkenhead.

1862. *Gatty, Charles Henry, M.A., LL.D., F.R.S.E., F.L.S., F.G.S. Felbridge Place, East Grinstead, Sussex.

1890. ‡Gaunt, Sir Edwin. Carlton Lodge, Leeds.

1875. ‡Gavey, J. Hollydale, Hampton Wick, Middlesex.

1892. ‡Geddes, George H. 8 Douglas-crescent, Edinburgh.

1871. ‡Geddes, John. 9 Melville-crescent, Edinburgh.

1885. ‡GEDDES, Professor PATRICK. Ramsay-garden, Edinburgh.

Year of Election.

1887. ‡Gee, W. W. Haldane. Owens College, Manchester.

1867. ‡GEIKIE, Sir ARCHIBALD, LL.D., D.Sc., F.R.S., F.R.S.E., F.G.S. (PRESIDENT, 1892; Pres. C, 1867, 1871, 1899; Council 1888–91). 10 Chester-terrace, Regent's-park, N.W.

1871. ‡GEIKIE, JAMES, LL.D., D.C.L., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1889; Pres. E, 1892), Murchison Professor of Geology and Mineralogy in the University of Edinburgh. Kilmorie, Colinton-road, Edinburgh.

1898. §Gemmill, James F., M.A., M.B. 16 Dargavel-avenue, Dumbreck, Glasgow.

1882. *GENESE, R. W., M.A., Professor of Mathematics in University College, Aberystwyth.

1875. *George, Rev. Hereford Brooke, M.A., F.R.G.S. Holywell Lodge, Oxford.

1902. *Gepp, Antony, M.A., F.L.S. British Museum (Natural History), Cromwell-road, S.W.

1885. ‡Gerard, Robert. Blair-Devenick, Cults, Aberdeen.

1884. *Gerrans, Henry T., M.A. 20 St. John-street, Oxford.

1884. ‡Gibb, Charles. Abbotsford, Quebec, Canada.

1865. ‡*Gibbins, William. Battery Works, Digbeth, Birmingham.*

1902. §Gibson, Andrew. 14 Cliftonville-avenue, Belfast.

1874. ‡Gibson, The Right Hon. Edward, K.C. 23 Fitzwilliam-square, Dublin.

1892. ‡Gibson, Francis Maitland. Care of Professor Gibson, 20 George-square, Edinburgh.

1901. §Gibson, Professor George A., M.A. 183 Renfrew-street, Glasgow.

1876. *Gibson, George Alexander, M.D., D.Sc., F.R.S.E. 3 Drumsheugh-gardens, Edinburgh.

1892. ‡Gibson, James. 20 George-square, Edinburgh.

1884. ‡Gibson, Rev. James J. 183 Spadina-avenue, Toronto, Canada.

1896. ‡GIBSON, R. J. HARVEY, M.A., F.R.S.E., Professor of Botany, University College, Liverpool.

1889. *Gibson, T. G. Lesbury House, Lesbury, R.S.O., Northumberland.

1893. ‡Gibson, Walcot, F.G.S. 28 Jermyn-street, S.W.

1887. *GIFFEN, Sir ROBERT, K.C.B., LL.D., F.R.S., V.P.S.S. (Pres. F, 1887, 1901). Chanctonbury, Hayward's Heath.

1898. *Gifford, J. William. Oaklands, Chard.

1884. ‡Gilbert E. E. 245 St. Antoine-street, Montreal, Canada.

1883. §Gilbert, Lady. Harpenden, near St. Albans.

1857. ‡Gilbert, J. T., M.R.I.A. Villa Nova, Blackrock, Dublin.

1884. *Gilbert, Philip H. 63 Tupper-street, Montreal, Canada.

1895. ‡Gilchrist, J. D. F. Carvenon, Anstruther, Scotland.

1896. *GILCHRIST, PERCY C., F.R.S., M.Inst.C.E. Frognal Bank, Finchley-road, Hampstead, N.W.

1878. ‡Giles, Oliver. Brynteg, The Crescent, Bromsgrove.

1871. *GILL, Sir DAVID, K.C.B., LL.D., F.R.S., F.R.A.S. Royal Observatory, Cape Town.

1902. §Gill, James F. 72 Strand-road, Bootle, Liverpool.

1884. ‡Gillman, Henry. 130 Lafayette-avenue, Detroit, Michigan, U.S.A.

1896. ‡Gilmour, H. B. Underlea, Aigburth, Liverpool.

1892. *Gilmour, Matthew A. B., F.Z.S. Saffronhall House, Windmill-road, Hamilton, N.B.

1867. ‡Gilroy, Robert. Craigie, by Dundee.

1893. *Gimingham, Edward. 1 Cranbourne-mansions, Cranbourne-street, W.C.

1900. §Ginsburg, Benedict W., M.A., LL.D. Royal Statistical Society, 9 Adelphi-terrace, W.C.

Year of Election.

1867. ‡GINSBURG, Rev. C. D., D.C.L., LL.D. Holmlea, Virginia Water Station, Chertsey.
1884. ‡Girdwood, Dr. G. P. 28 Beaver Hall-terrace, Montreal, Canada.
1886. *Gisborne, Hartley, M.Can.S.C.E. Caragana Lodge, Ladysmith, Vancouver Island, Canada.
1850. *Gladstone, George, F.R.G.S. 34 Denmark-villas, Hove, Brighton.
1883. *Gladstone, Miss. 17 Pembridge-square, W.
1871. *GLAISHER, J. W. L., M.A., D.Sc., F.R.S., F.R.A.S. (Pres. A, 1890; Council 1878–86). Trinity College, Cambridge.
1901. ‡Glaister, Professor John, M.D., F.R.S.E. 18 Woodside-place, Glasgow.
1897. ‡Glashan, J. C., LL.D. Ottawa, Canada.
1883. ‡Glasson, L. T. 2 Roper-street, Penrith.
1881. *GLAZEBROOK, R. T., M.A., D.Sc., F.R.S., Director of the National Physical Laboratory (Pres. A, 1893; Council 1890–94). Bushy House, Teddington, Middlesex.
1881. *Gleadow, Frederic. 38 Ladbroke-grove, W.
1859. ‡Glennie, J. S. Stuart, M.A. Verandah Cottage, Haslemere, Surrey.
1874. ‡Glover, George T. Corby, Hoylake.
Glover, Thomas. 124 Manchester-road, Southport.
1870. ‡Glynn, Thomas R., M.D. 62 Rodney-street, Liverpool.
1872. ‡GODDARD, RICHARD (Local Sec. 1873). 16 Booth-street, Bradford, Yorkshire.
1899. §Godfrey, Ingram F. Brooke House, Ash, Dover.
1886. ‡Godlee, Arthur. The Lea, Harborne, Birmingham.
1887. ‡Godlee, Francis. 8 Minshall-street, Manchester.
1878. *Godlee, J. Lister. Wakes Colne Place, Essex.
1880. ‡GODMAN, F. DU CANE, D.C.L., F.R.S., F.L.S., F.G.S. 10 Chandos-street, Cavendish-square, W.
1883. ‡Godson, Dr. Alfred. Cheadle, Cheshire.
1852. ‡Godwin, John. Wood House, Rostrevor, Belfast.
1879. ‡GODWIN-AUSTEN, Lieut.-Colonel H. H., F.R.S., F.R.G.S., F.Z.S. (Pres. E, 1883). Nore, Godalming.
1876. ‡Goff, Bruce, M.D. Bothwell, Lanarkshire.
1898. ‡Goldney, F. B. Goodnestone Park, Dover.
1881. ‡GOLDSCHMIDT, EDWARD, J.P. Nottingham.
1886. ‡GOLDSMID, Major-General Sir F. J., K.C.S.I., C.B., F.R.G.S. (Pres. E, 1886). Godfrey House, Hollingbourne.
1899. ‡GOMME, G. L., F.S.A. 24 Dorset-square, N.W.
1890. *GONNER, E. C. K., M.A. (Pres. F, 1897), Professor of Political Economy in University College, Liverpool.
1884. ‡Good, Charles E. 102 St. François Xavier-street, Montreal, Canada.
1852. ‡Goodbody, Jonathan. Clare, King's County, Ireland.
1878. ‡Goodbody, Jonathan, jun. 50 Dame-street, Dublin.
1884. ‡Goodbody, Robert. Fairy Hill, Blackrock, Co. Dublin.
1885. ‡GOODMAN, J. D., J.P. Peachfield, Edgbaston, Birmingham.
1884. *Goodridge, Richard E. W. Lupton, Michigan, U.S.A.
1884. ‡Goodwin, Professor W. L. Queen's University, Kingston, Ontario, Canada.
1885. ‡Gordon, Rev. Cosmo, D.D., F.R.A.S. Chetwynd Rectory, Newport, Salop.
1871. *Gordon, Joseph Gordon, F.C.S. Queen Anne's-mansions, Westminster, S.W.
1893. ‡Gordon, Mrs. M. M., D.Sc. 1 Rubislaw-terrace, Aberdeen.
1884. *Gordon, Robert, M.Inst.C.E., F.R.G.S. Fairview, Dartmouth, Devon.

Year of Election.

1899. §Gordon, T. Kirkman. 15 Hampden-street, Nottingham.

1885. ‡Gordon, Rev. William. Braemar, N.B.

1865. ‡GORE, GEORGE, LL.D., F.R.S. 20 Easy-row, Birmingham.

1901. §GORST, Right Hon. Sir JOHN E., M.A., K.C., M.P., F.R.S. (Pres. L. 1901). Queen Anne's-mansions, S.W.

1875. *GOTCH, FRANCIS, M.A., B.Sc., F.R.S. (Council, 1901–), Professor of Physiology in the University of Oxford. The Lawn, Banbury-road, Oxford.

1873. ‡Gott, Charles, M.Inst.C.E. Parkfield-road, Manningham, Bradford, Yorkshire.

1849. ‡Gough, The Hon. Frederick. Perry Hall, Birmingham.

1881. ‡Gough, Rev. Thomas, B.Sc. King Edward's School, Retford.

1894. ‡Gould, G. M., M.D. 119 South 17th-street, Philadelphia, U.S.A.

1888. ‡Gouraud, Colonel. Gwydyr-mansions, Hove, Sussex.

1901. ‡GOURLAY, ROBERT. Glasgow.

1867. ‡Gourley, Henry (Engineer). Dundee.

1901. §Gow, Leonard. Hayston, Kelvinside, Glasgow.

1876. ‡Gow, Robert. Cairndowan, Dowanhill-gardens, Glasgow.

1883. §Gow, Mrs. Cairndowan, Dowanhill-gardens, Glasgow.

1873. §Goyder, Dr. D. Marley House, 88 Great Horton-road, Bradford, Yorkshire.

1886. ‡Grabham, Michael C., M.D. Madeira.

1901. §Graham, Robert. 165 Nithsdale-road, Pollokshields, Glasgow.

1902. *Graham, William, M.D. District Lunatic Asylum, Belfast.

1875. ‡GRAHAME, JAMES (Local Sec. 1876). Reform Club, Pall Mall, S.W.

1892. ‡Grange, C. Ernest. 57 Berners-street, Ipswich.

1893. ‡Granger, Professor F. S., M.A., D.Litt. 2 Cranmer-street, Nottingham.

1896. ‡Grant, Sir James, K.C.M.G. Ottawa, Canada.

1892. ‡Grant, W. B. 10 Ann-street, Edinburgh.

1864. ‡Grantham, Richard F., M.Inst.C.E., F.G.S. Northumberland-chambers, Northumberland-avenue, W.C.

1881. ‡Gray, Alan, LL.B. Minster-yard, York.

1899. ‡Gray, Albert Alexander. 16 Berkeley-terrace, Glasgow.

1890. ‡GRAY, ANDREW, M.A., LL.D., F.R.S., F.R.S.E., Professor of Natural Philosophy in the University of Glasgow.

1899. ‡Gray, Charles. 11 Portland-place, W.

1902. §Gray, G., M.D. Newcastle, Co. Down.

1864. *Gray, Rev. Canon Charles. West Retford Rectory, Retford.

1876. ‡Gray, Dr. Newton-terrace, Glasgow.

1881. ‡Gray, Edwin, LL.B. Minster-yard, York.

1893. ‡Gray, J. C., General Secretary of the Co-operative Union, Limited, Long Millgate, Manchester.

1892. *Gray, James Hunter, M.A., B.Sc. 141 Hopton-road, Streatham, S.W.

1870. ‡Gray, J. Macfarlane. 4 Ladbroke-crescent, W.

1892. §GRAY, JOHN, B.Sc. 9 Park-hill, Clapham Park, S.W.

1887. ‡Gray, Joseph W., F.G.S. St. Elmo, Leckhampton-road, Cheltenham.

1887. ‡Gray, M. H., F.G.S. Lessness Park, Abbey Wood, Kent.

1886. *Gray, Robert Kaye. Lessness Park, Abbey Wood, Kent.

1901. ‡Gray, R. W. 7 Orme-court, Bayswater, W.

1881. ‡Gray, Thomas, Professor of Engineering in the Rane Technical Institute, Terre Haute, Indiana, U.S.A.

1873. ‡Gray, William, M.R.I.A. Glenburn Park, Belfast.

*GRAY, Colonel WILLIAM. Farley Hall, near Reading.

Year of Election.

1883. ‡Gray, William Lewis. Westmoor Hall, Brimsdown, Middlesex.
1883. ‡Gray, Mrs. W. L. Westmoor Hall, Brimsdown, Middlesex.
1886. ‡Greaney, Rev. William. Bishop's House, Bath-street, Birmingham.
1866. §Greaves, Charles Augustus, M.B., LL.B. 84 Friar-gate, Derby.
1893. *Greaves, Mrs. Elizabeth. Station-street, Nottingham.
1869. ‡Greaves, William. Station-street, Nottingham.
1872. ‡Greaves, William. 33 Marlborough-place, N.W.
1872. *Grece, Clair J., LL.D. 146 Station-road, Redhill, Surrey.
1901. *Green, F. W. Edridge, M.D., F.R.C.S. 14 Welbeck-street, W.
1888. §GREEN, J. REYNOLDS, M.A., D.Sc., F.R.S., F.L.S. (Pres. K, 1902), Professor of Botany to the Pharmaceutical Society of Great Britain. 61A St. Andrew's-street, Cambridge.
1882. ‡GREENHILL, A. G., M.A., F.R.S., Professor of Mathematics in the Royal Artillery College, Woolwich. 11 New Inn, W.C.
1881. ‡Greenhough, Edward. Matlock Bath, Derbyshire.
1884. ‡Greenish, Thomas, F.C.S. 20 New-street, Dorset-square, N.W.
1898. *GREENLY, EDWARD. Achnashean, near Bangor, North Wales.
1884. ‡Greenshields, E. B. Montreal, Canada.
1884. ‡Greenshields, Samuel. Montreal, Canada.
1887. ‡Greenwell, G. C. Beechfield, Poynton, Cheshire.
1863. ‡Greenwell, G. E. Poynton, Cheshire.
1890. ‡Greenwood, Arthur. Cavendish-road, Leeds.
1875. ‡Greenwood, F., M.B. Brampton, Chesterfield.
1877. ‡*Greenwood, Holmes. 78 King Street, Accrington.*
1887. ‡Greenwood, W. H., M.Inst.C.E. Adderley Park Rolling Mills, Birmingham.
1887. *Greg, Arthur. Eagley, near Bolton, Lancashire.
1861. *GREG, ROBERT PHILIPS, F.G.S., F.R.A.S. Coles Park, Buntingford, Herts.
1894. *GREGORY, Professor J. WALTER, D.Sc., F.R.S., F.G.S. The University, Melbourne, Australia.
1896. *Gregory, Professor R. A., F.R.A.S. Dell Quay House, near Chichester.
1883. ‡Gregson, G. E. Ribble View, Preston.
1881. ‡Gregson, William, F.G.S. Baldersby, S.O., Yorkshire.
1859. ‡GRIERSON, THOMAS BOYLE, M.D. Thornhill, Dumfriesshire.
1878. ‡Griffin, Robert, M.A., LL.D. Trinity College, Dublin.
1836. Griffin, S. F. Albion Tin Works, York-road, N.
1894. *Griffith, C. L. T., Assoc.M.Inst.C.E. Portland Cement Co., Demopolis, Alabama, U.S.A.
1884. ‡GRIFFITHS, E. H., M.A., D.Sc., F.R.S. University College, Cardiff.
1884. ‡Griffiths, Mrs. University College, Cardiff.
1891. ‡Griffiths, P. Rhys, B.Sc., M.B. 71 Newport-road, Cardiff.
1847. ‡Griffiths, Thomas. The Elms, Harborne-road, Edgbaston, Birmingham.
1870. ‡Grimsdale, T. F., M.D. Hoylake, Liverpool.
1888. *Grimshaw, James Walter, M.Inst.C.E. Australian Club, Sydney, New South Wales.
1884. ‡Grinnell, Frederick. Providence, Rhode Island, U.S.A.
1894. ‡GROOM, Professor P., M.A., F.L.S. Hollywood, Egham, Surrey.
1894. §Groom, T. T., D.Sc. The Poplars, Hereford.
1896. ‡Grossmann, Dr. Karl. 70 Rodney-street, Liverpool.
1892. ‡Grove, Mrs. Lilly, F.R.G.S. The University, Birmingham.
1891. ‡Grover, Henry Llewellin. Clydach Court, Pontypridd.
1863. *GROVES, THOMAS B. Broadley, Westerhall-road, Weymouth.
1869. ‡GRUBB, Sir HOWARD, F.R.S., F.R.A.S. 51 Kenilworth-square, Rathgar, Dublin.

Year of Election.

1897. ‡Grünbaum, A. S., M.A., M.D. 45 Ladbroke-grove, W.

1897. ‡Grünbaum, O. F. F., B.A., D.Sc. 45 Ladbroke-grove, W.

1886. ‡Grundy, John. 17 Private-road, Mapperley, Nottingham.

1891. ‡Grylls, W. London and Provincial Bank, Cardiff.

1887. ‡GUILLEMARD, F. H. H. Eltham, Kent.

Guinness, Henry. 17 College-green, Dublin.

1842. Guinness, Richard Seymour. 17 College-green, Dublin.

1891. ‡Gunn, Sir John. Llandaff House, Llandaff.

1877. ‡Gunn, William, F.G.S. Office of the Geological Survey of Scotland, Sheriff's Court House, Edinburgh.

1866. ‡GÜNTHER, ALBERT C. L. G., M.A., M.D., Ph.D., F.R.S., F.L.S., F.Z.S. (Pres. D, 1880). 22 Lichfield-road, Kew, Surrey.

1894. ‡Günther, R. T. Magdalen College, Oxford.

1880. §Guppy, John J. Ivy-place, High-street, Swansea.

1902. *Gurney, Robert. The Laboratory, Citadel Hill, Plymouth.

1883. ‡Guthrie, Malcolm. Prince's-road, Liverpool.

1896. ‡Guthrie, Tom, B.Sc. Yorkshire College, Leeds.

1876. ‡GWYTHER, R. F., M.A. Owens College and 33 Heaton-road, Withington, Manchester.

1884. ‡Haanel, E., Ph.D. Cobourg, Ontario, Canada.

1884. ‡Hadden, Captain C. F., R.A. Woolwich.

1881. *HADDON, ALFRED CORT, M.A., D.Sc., F.R.S., F.Z.S. (Pres. H, 1902; Council, 1902–). Inisfail, Hills-road, Cambridge.

1888. *Hadfield, R. A., M.Inst.C.E. The Grove, Endcliffe Vale-road, Sheffield.

1892. ‡*Haigh, E., M.A. Longton, Staffordshire.*

1870. ‡Haigh, George. 27 Highfield South, Rockferry, Cheshire.

1879. ‡HAKE, H. WILSON, Ph.D., F.C.S. Queenwood College, Hants.

1899. ‡Hall, A. D., M.A., Director of the Rothamsted Experiment Station.

1879. *Hall, Ebenezer. Abbeydale Park, near Sheffield.

1883. *Hall, Miss Emily. 15 Belmont-street, Southport.

1881. ‡Hall, Frederick Thomas, F.R.A.S. 15 Gray's Inn-square, W.C.

1902. §Hall, Henry Sinclair. 6 The Avenue, Clifton, Bristol.

1854. *HALL, HUGH FERGIE, F.G.S. Cissbury Court, West Worthing, Sussex.

1898. §Hall, James P. The 'Tribune,' New York, U.S.A.

1899. ‡Hall, John, M.D. National Bank of Scotland, 37 Nicholas-lane, E.C

1885. §Hall, Samuel, F.I.C., F.C.S. 19 Aberdeen-park, Highbury, N.

1900. ‡Hall, T. Farmer, F.R.G.S. 39 Gloucester-square, Hyde Park, W.

1896. ‡Hall, Thomas B. Larch Wood, Rockferry, Cheshire.

1884. ‡Hall, Thomas Proctor. School of Practical Science, Toronto, Canada.

1896. ‡Hall-Dare, Mrs. Caroline. 13 Great Cumberland-place, W.

1891. *Hallett, George. Cranford, Victoria-road, Penarth, Glamorganshire.

1891. ‡Hallett, J. H., M.Inst.C.E. Maindy Lodge, Cardiff.

1873. *HALLETT, T. G. P., M.A. Claverton Lodge, Bath.

1888. §HALLIBURTON, W. D., M.D., F.R.S. (Pres. I, 1902; Council 1897–), Professor of Physiology in King's College, London. Church Cottage, 17 Marylebone-road, N.W.

Halsall, Edward. 4 Somerset-street, Kingsdown, Bristol.

1858. *Hambly, Charles Hambly Burbridge, F.G.S. Fairley, Weston, Bath.

1883. *Hamel, Egbert D. de. Middleton Hall, Tamworth.

1885. ‡Hamilton, David James. 41 Queen's-road, Aberdeen.

1902. ‡HAMILTON, Rev. T., D.D. Queen's College, Belfast.

1881. *Hammond, Robert. 64 Victoria-street, Westminster, S.W.

ear of
lection.

899. *Hanbury, Daniel. La Mortola, Ventimiglia, Italy.
892. ‡Hanbury, Thomas, F.L.S. La Mortola, Ventimiglia, Italy.
878. ‡Hance, Edward M., LL.B. Municipal Offices, Liverpool.
875. ‡Hancock, C. F., M.A. 125 Queen's-gate, S.W.
897. ‡HANCOCK, HARRIS. University of Chicago, U.S.A.
861. ‡Hancock, Walter. 10 Upper Chadwell-street, Pentonville, E.C.
890. ‡Hankin, Ernest Hanbury. St. John's College, Cambridge.
884. ‡Hannaford, E. P., M.Inst.C.E. 2573 St. Catherine-street, Montreal.
1894. §Hannah, Robert, F.G.S. 82 Addison-road, W.
1886. §Hansford, Charles, J.P. Englefield House, Dorchester.
1902. §Harbison, Adam, B.A. 5 Ravenhill-terrace, Ravenhill-road, Belfast.
1859. *HARCOURT, A. G. VERNON, M.A., D.C.L., LL.D., F.R.S., V.P.C.S. (GEN. SEC. 1883–97; Pres. B, 1875; Council 1881–83). St. Clare, Ryde, Isle of Wight.
1890. *HARCOURT, L. F. VERNON, M.A., M.Inst.C.E. (Pres. G, 1895; Council 1895–1901). 6 Queen Anne's-gate, S.W.
1900. ‡Harcourt, Hon. R., K.C., Minister of Education for the Province of Ontario. Toronto, Canada.
1886. *Hardcastle, Basil W., F.S.S. 12 Gainsborough-gardens, Hampstead, N.W.
1902. §Hardcastle, Miss Frances. 141 Huntingdon-road, Cambridge.
1892. *HARDEN, ARTHUR, Ph.D., M.Sc. Jenner Institute of Preventive Medicine, Chelsea-gardens, Grosvenor-road, S.W.
1877. ‡Harding, Stephen. Bower Ashton, Clifton, Bristol.
1869. ‡Harding, William D. Islington Lodge, King's Lynn, Norfolk.
1894. ‡Hardman, S. C. 120 Lord-street, Southport.
1894. ‡Hare, A. T., M.A. Neston Lodge, East Twickenham, Middlesex.
1894. ‡Hare, Mrs. Neston Lodge, East Twickenham, Middlesex.
1898. ‡Harford, W. H. Oldown House, Almondsbury.
1858. ‡Hargrave, James. Burley, near Leeds.
1883. ‡Hargreaves, Miss H. M. 69 Alexandra-road, Southport.
1883. ‡Hargreaves, Thomas. 69 Alexandra-road, Southport.
1890. ‡Hargrove, Rev. Charles. 10 De Grey-terrace, Leeds.
1881. ‡Hargrove, William Wallace. St. Mary's, Bootham, York.
1890. *HARKER, ALFRED, M.A., F.R.S., F.G.S. St. John's College, Cambridge.
1896. ‡Harker, Dr. John Allen. Springfield House, Stockport.
1887. ‡Harker, T. H. Brook House, Fallowfield, Manchester.
1871. ‡*Harkness, William, F.C.S. 1 St. Mary's-road, Canonbury, N.*
1875. *Harland, Rev. Albert Augustus, M.A., F.G.S., F.L.S., F.S.A. The Vicarage, Harefield, Middlesex.
1877. *Harland, Henry Seaton. 8 Arundel-terrace, Brighton.
1883. *Harley, Miss Clara. Rosslyn, Westbourne-road, Forest Hill, S.E.
1883. *Harley, Harold. 14 Chapel-street, Bedford-row, W.C.
1862. *HARLEY, Rev. ROBERT, M.A., F.R.S., F.R.A.S. Rosslyn, Westbourne-road, Forest Hill, S.E.
1899. ‡Harman, Dr. N. Bishop. St. John's College, Cambridge.
1868. *HARMER, F. W., F.G.S. Oakland House, Cringleford, Norwich.
1881. *HARMER, SIDNEY F., M.A., D.Sc., F.R.S. King's College, Cambridge.
1872. ‡Harpley, Rev. William, M.A. Clayhanger Rectory, Tiverton.
1884. ‡Harrington, B. J., B.A., Ph.D., F.G.S., Professor of Chemistry and Mineralogy in McGill University, Montreal. University-street, Montreal, Canada.
1888. ‡Harris, C. T. 4 Kilburn Priory, N.W.
1842. *Harris, G. W., M.Inst.C.E. Millicent, South Australia.

Year of Election.

1889. §HARRIS, H. GRAHAM, M.Inst.C.E. 5 Great George-street, Westminster, S.W.
1898. ‡Harrison, A. J., M.D. Failand Lodge, Guthrie-road, Clifton, Bristol.
1888. ‡Harrison, Charles. 20 Lennox-gardens, S.W.
1860. ‡Harrison, Rev. Francis, M.A. North Wraxall, Chippenham.
1889. ‡Harrison, J. C. Oxford House, Castle-road, Scarborough.
1858. *HARRISON, J. PARK, M.A. 22 Connaught-street, Hyde Park, W.
1892. ‡HARRISON, JOHN (Local Sec. 1892). Rockville, Napier-road, Edinburgh.
1870. ‡HARRISON, REGINALD, F.R.C.S. (Local Sec. 1870). 6 Lower Berkeley-street, Portman-square, W.
1853. ‡Harrison, Robert. 36 George-street, Hull.
1892. ‡Harrison, Rev. S. N. Ramsey, Isle of Man.
1895. ‡Harrison, Thomas. 48 High-street, Ipswich.
1901. *Harrison, W. E. 43 Mostyn-road, Handsworth, Staffordshire.
1886. ‡Harrison, W. Jerome, F.G.S. Board School, Icknield-street, Birmingham.
1885. ‡HART, Colonel C. J. (Local Sec. 1886.) Highfield Gate, Edgbaston, Birmingham.
1876. *Hart, Thomas. Brooklands, Blackburn.
1875. ‡Hart, W. E. Kilderry, near Londonderry.
1893. *HARTLAND, E. SIDNEY, F.S.A. Highgarth, Gloucester.
1897. ‡Hartley, E. G. S. Wheaton Astley Hall, Stafford.
1871. *HARTLEY, WALTER NOEL, D.Sc., F.R.S., F.R.S.E., F.C.S., Professor of Chemistry in the Royal College of Science, Dublin. 36 Waterloo-road, Dublin.
1896. ‡Hartley, W. P., J.P. Aintree, Liverpool.
1886. *HARTOG, Professor M. M., D.Sc. Queen's College, Cork.
1887. ‡HARTOG, P. J., B.Sc. Owens College, Manchester.
1897. ‡Harvey, Arthur. Rosedale, Toronto, Canada.
1898. ‡Harvey, Eddie. 10 The Paragon, Clifton, Bristol.
1885. §Harvie-Brown, J. A. Dunipace, Larbert, N.B.
1862. *Harwood, John. Woodside Mills, Bolton-le-Moors.
1884. ‡Haslam, Rev. George, M.A. Trinity College, Toronto, Canada.
1893. §Haslam, Lewis. 44 Evelyn-gardens, S.W.
1875. *HASTINGS, G. W. (Pres. F, 1880.) Chapel House, Chipping Norton.
1889. ‡Hatch, F. H., Ph.D., F.G.S. 28 Jermyn-street, S.W.
1893. ‡Hatton, John L. S. People's Palace, Mile End-road, E.
1887. *Hawkins, William. Earlston House, Broughton Park, Manchester.
1872. *Hawkshaw, Henry Paul. 58 Jermyn-street, St. James's, S.W.
1864. *HAWKSHAW, JOHN CLARKE, M.A., M.Inst.C.E., F.G.S. (Council 1881–87). 22 Down-street, W., and 33 Great George-street, S.W.
1897. §HAWKSLEY, CHARLES, M.Inst.C.E. (Council, 1902–). 60 Porchester-terrace, W.
1889. ‡Haworth, George C. Ordsal, Salford.
1887. *Haworth, Jesse. Woodside, Bowdon, Cheshire.
1890. ‡Hawtin, J. N. Sturdie House, Roundhay-road, Leeds.
1861. *HAY, Admiral the Right Hon. Sir JOHN C. D., Bart., G.C.B., D.C.L., F.R.S. 108 St. George's-square, S.W.
1885. *HAYCRAFT, JOHN BERRY, M.D., B.Sc., F.R.S.E., Professor of Physiology. University College, Cardiff.
1891. ‡Hayde, Rev. J. St. Peter's, Cardiff.
1900. §Hayden, H. H. Geological Survey, Calcutta, India.
1894. ‡Hayes, Edward Harold. 5 Rawlinson-road, Oxford.
1896. ‡Hayes, Rev. F. C. The Rectory, Raheny, Dublin.
1896. ‡Hayes, William. Fernyhurst, Rathgar, Dublin.

Year of
Election.

1873. *Hayes, Rev. William A., M.A. Dromore, Co. Down, Ireland.
1898. ‡Hayman, C. A. Kingston Villa, Richmond Hill, Clifton, Bristol.
1858. *HAYWARD, R. B., M.A., F.R.S. Ashcombe, Shanklin, Isle of Wight.
1896. *Haywood, A. G. Rearsby, Merrilocks-road, Blundellsands.
1879. *Hazelhurst, George S. The Grange, Rockferry.
1883. ‡Headley, Frederick Halcombe. Manor House, Petersham, S.W.
1883. ‡Headley, Mrs. Marian. Manor House, Petersham, S.W.
1883. ‡Headley, Rev. Tanfield George. Manor House, Petersham, S.W.
1883. ‡Heape, Charles. Tovrak, Oxton, Cheshire.
1883. ‡Heape, Joseph R. Glebe House, Rochdale.
1882. *Heape, Walter, M.A. Heyroun, Chaucer-road, Cambridge.
1877. ‡Hearder, Henry Pollington. Westwell-street, Plymouth.
1877. ‡Hearder, William Keep. 195 Union-street, Plymouth.
1898. *Heath, Rev. Arthur J. 71 St. Michael's-hill, Redland, Bristol.
1902. §Heath, J. W. 33 Upper Gloucester-place, Dorset-square, N.W.
1898. ‡HEATH, R. S., M.A., D.Sc. The University, Birmingham.
1884. ‡Heath, Thomas, B.A. Royal Observatory, Edinburgh.
1902. §Heathorn, Captain T. B., R.A. 10 Wilton-place, Knightsbridge, S.W.
1883. ‡Heaton, Charles. Marlborough House, Hesketh Park, Southport.
1892. *HEATON, WILLIAM H., M.A. (Local Sec. 1893), Professor of Physics in University College, Nottingham.
1889. *Heaviside, Arthur West. 7 Grafton-road, Whitley, Newcastle-upon-Tyne.
1884. §Heaviside, Rev. George, B.A., F.R.G.S., F.R.Hist.S. 7 Grosvenor-street, Coventry.
1888. *Heawood, Edward, M.A. 3 Underhill-road, Lordship-lane, S.E.
1888. *Heawood, Percy J., Lecturer in Mathematics at Durham University. 41 Old Elvet, Durham.
1855. ‡HECTOR, Sir JAMES, K.C.M.G., M.D., F.R.S., F.G.S., Director of the Geological Survey of New Zealand. Wellington, New Zealand.
1887. *HEDGES, KILLINGWORTH, M.Inst.C.E. 10 Cranley-place, South Kensington, S.W.
1881. *HELE-SHAW, H. S., LL.D., F.R.S., M.Inst.C.E., Professor of Engineering in University College, Liverpool. 27 Ullet-road, Liverpool.
1901. §Heller, W. M., B.Sc. 18 Belgrave-square, Monkstown, Co. Dublin.
1887. §Hembry, Frederick William, F.R.M.S. Langford, Sidcup, Kent.
1897. §Hemming, G. W., K.C. 2 Earl's Court-square, S.W.
1899. §Hemsalech, G. A., D.Sc. 507 Stretford-road, Manchester.
1867. ‡Henderson, Alexander. Dundee.
1873. *Henderson, A. L. Westmoor Hall, Brimsdown, Middlesex.
1883. ‡Henderson, Mrs. A. L. Westmoor Hall, Brimsdown, Middlesex.
1901. §Henderson, Rev. Andrew, LL.D. Castle Head, Paisley.
1891. *HENDERSON, G. G., D.Sc., M.A., F.C.S., F.I.C., Professor of Chemistry in the Glasgow and West of Scotland Technical College. 204 George-street, Glasgow.
1892. ‡Henderson, John. 3 St. Catherine-place, Grange, Edinburgh.
1885. ‡Henderson, Sir William. Devanha House, Aberdeen.
1880. *Henderson, Rear-Admiral W. H., R.N. Royal Dockyard, Devonport.
1896. ‡Henderson, W. Saville, B.Sc. Beech Hill, Fairfield, Liverpool.
1873. *HENRICI, OLAUS M. F. E., Ph.D., F.R.S. (Pres. A, 1883; Council, 1883–89), Professor of Mechanics and Mathematics in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 34 Clarendon-road, Notting Hill, W.
1892. ‡HEPBURN, DAVID, M.D., F.R.S.E. The University, Edinburgh.
1855. *Hepburn, J. Gotch, LL.B., F.C.S. Oakfield Cottage, Dartford Heath, Kent.

Year of Election.

1890. ‡Hepper, J. 43 Cardigan-road, Headingley, Leeds.
1890. ‡Hepworth, Joseph. 25 Wellington-street, Leeds.
1892. *HERBERTSON, ANDREW J., Ph.D., F.R.S.E., F.R.G.S. 9 Staverton-road, Oxford.
1902. §Herdman, G. W., B.Sc., Assoc.M.Inst.C.E. 2 Fyfield-road, Enfield.
1887. *HERDMAN, WILLIAM A., D.Sc., F.R.S., F.R.S.E., F.L.S. (Pres. D, 1895; Council, 1894–1900; Local Sec. 1896), Professor of Natural History in University College, Liverpool. Croxteth Lodge, Sefton Park, Liverpool.
1893. *Herdman, Mrs. Croxteth Lodge, Sefton Park, Liverpool.
1891. ‡*Hern, S. South Cliff, Marine Parade, Penarth.*
1871. *HERSCHEL, ALEXANDER S., M.A., D.C.L., F.R.S., F.R.A.S., Honorary Professor of Physics and Experimental Philosophy in the University of Durham. Observatory House, Slough, Bucks.
1874. §HERSCHEL, Colonel JOHN, R.E., F.R.S., F.R.A.S. Observatory House, Slough, Bucks.
1900. *Herschel, J. C. W. Littlemore, Oxford.
1900. ‡Herschel, Sir W. J., Bart. Littlemore, Oxford.
1895. §Hesketh, James. Scarisbrick Avenue-buildings, 107 Lord-street, Southport.
1894. ‡HEWETSON, G. H. (Local Sec. 1896). 39 Henley-road, Ipswich.
1894. ‡Hewins, W. A. S., M.A., F.S.S. Professor of Political Economy in King's College, Strand, W.C.
1896. §Hewitt, David Basil. Oakleigh, Northwich, Cheshire.
1893. ‡Hewitt, Thomas P. Eccleston Park, Prescot, Lancashire.
1883. ‡Hewson, Thomas. Junior Constitutional Club, Piccadilly, W.
1882. ‡HEYCOCK, CHARLES T., M.A., F.R.S. King's College, Cambridge.
1883. §Heyes, Rev. John Frederick, M.A., F.R.G.S. 90 Arkwright-street, Bolton.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1897. ‡Heys, Thomas. 130 King-street West, Toronto, Canada.
1901. *Heys, Z. John. Stonehouse, Barrhead, N.B.
1879. ‡Heywood, Sir A. Percival, Bart. Duffield Bank, Derby.
1886. ‡HEYWOOD, HENRY, J.P. Witla Court, near Cardiff.
1887. ‡Heywood, Robert. Mayfield, Victoria Park, Manchester.
1888. ‡Hichens, James Harvey, M.A. The School House, Wolverhampton.
1898. §Hicks, Henry B. 44 Pembroke-road, Clifton, Bristol.
1877. §HICKS, Professor W. M., M.A., D.Sc., F.R.S. (Pres. A, 1895), Principal of University College, Sheffield. Dunheved, Endcliffe-crescent, Sheffield.
1886. ‡Hicks, Mrs. W. M. Dunheved, Endcliffe-crescent, Sheffield.
1884. ‡Hickson, Joseph. 272 Mountain-street, Montreal, Canada.
1887. *HICKSON, SYDNEY J., M.A., D.Sc., F.R.S., Professor of Zoology in Owens College, Manchester.
1864. *HIERN, W. P., M.A. The Castle, Barnstaple.
1891. ‡HIGGS, HENRY, LL.B., F.S.S. (Pres. F, 1899). H.M. Treasury, Whitehall, S.W.
1885. *HILL, ALEXANDER, M.A., M.D. Downing College, Cambridge.
1898. ‡Hill, Charles. Clevedon.
*Hill, Rev. Canon Edward, M.A. Sheering Rectory, Harlow.
1881. *HILL, Rev. EDWIN, M.A. The Rectory, Cockfield, Bury St. Edmunds.
1887. ‡Hill, G. H., M.Inst.C.E., F.G.S. Albert-chambers, Albert-square, Manchester.
1884. ‡Hill, Rev. James Edgar, M.A., B.D. 2488 St. Catherine-street, Montreal, Canada.

Year of Election.

1886. ‡HILL, M. J. M., M.A., D.Sc., F.R.S., Professor of Pure Mathematics in University College, W.C.

1885. *Hill, Sidney. Langford House, Langford, Bristol.

1898. *Hill, Thomas Sidney. Langford House, Langford, Bristol.

1888. ‡Hill, William. Hitchin, Herts.

1876. ‡Hill, William H. Barlanark, Shettleston, N.B.

1885. *HILLHOUSE, WILLIAM, M.A., F.L.S., Professor of Botany in the University, Birmingham. 16 Duchess-road, Edgbaston, Birmingham.

1886. §Hillier, Rev. E. J. Cardington Vicarage, near Bedford.

1887. ‡Hilton, Edwin. Oak Bank, Fallowfield, Manchester.

1870. ‡HINDE, G. J., Ph.D., F.R.S., F.G.S. Ivythorn, Avondale-road, South Croydon, Surrey.

1883. *Hindle, James Henry. 8 Cobham-street, Accrington.

1888. *Hindmarsh, William Thomas, F.L.S. Alnbank, Alnwick.

1898. §Hinds, Henry. 57 Queen-street, Ramsgate.

1886. ‡Hingley, Sir Benjamin, Bart. Hatherton Lodge, Cradley, Worcestershire.

1881. ‡Hingston, J. T. Clifton, York.

1884. ‡HINGSTON, Sir WILLIAM HALES, M.D., D.C.L. 37 Union-avenue, Montreal, Canada.

1900. §Hinks, Arthur R., M.A. 10 Huntingdon-road, Cambridge.

1884. ‡Hirschfilder, C. A. Toronto, Canada.

1899. §Hobday, Henry. Hazelwood, Crabble Hill, Dover.

1879. ‡Hobkirk, Charles P., F.L.S. The Headlands, Scotland-lane, Horsforth, near Leeds.

1887. *Hobson, Bernard, M.Sc., F.G.S. Tapton Elms, Sheffield.

1883. ‡Hobson, Mrs. Carey. 5 Beaumont-crescent, West Kensington, W.

1883. ‡Hobson, Rev. E. W. 55 Albert-road, Southport.

1877. ‡Hodge, Rev. John Mackey, M.A. 38 Tavistock-place, Plymouth.

1876. ‡Hodges, Frederick W. Queen's College, Belfast.

1863. *HODGKIN, THOMAS, B.A., D.C.L. Benwell Dene, Newcastle-upon-Tyne.

1887. *Hodgkinson, Alexander, M.B., B.Sc., Lecturer on Laryngology at Owens College, Manchester. 18 St. John-street, Manchester.

1896. ‡Hodgkinson, Arnold. 22 Park-road, Southport.

1880. §Hodgkinson, W. R. Eaton, Ph.D., F.R.S.E., F.G.S., Professor of Chemistry and Physics in the Royal Artillery College, Woolwich. 18 Glenluce-road, Blackheath, S.E.

1884. ‡Hodgson, Jonathan. Montreal, Canada.

1863. ‡Hodgson R. W. 7 Sandhill, Newcastle-upon-Tyne.

1898. ‡Hodgson, T. V. Municipal Museum and Art Gallery, Plymouth.

1896. ‡Hodgson, Dr. Wm., J.P. Helensville, Crewe.

1894. ‡Hogg, A. F., M.A. 13 Victoria-road, Darlington.

1894. ‡Holah, Ernest. 5 Crown-court, Cheapside, E.C.

1883. ‡*Holden, Edward. Laurel Mount, Shipley, Yorkshire.*

1883. ‡Holden, James. 12 Park-avenue, Southport.

1883. ‡Holden, John J. 73 Albert-road, Southport.

1884. ‡Holden, Mrs. Mary E. Dunham Ladies' College, Quebec, Canada.

1887. *Holder, Henry William, M.A. Sheet, near Petersfield.

1896. ‡Holder, Thomas. 2 Tithebarn-street, Liverpool.

1900. §HOLDICH, Colonel Sir THOMAS H., R.E., K.C.B., K.C.I.E., F.R.G.S. (Pres. E, 1902). 23 Lansdowne-crescent, W.

1887. *Holdsworth, C. J. Sunnyside, Wilmslow, Cheshire.

1891. ‡Holgate, Benjamin, F.G.S. The Briers, North Park Avenue, Roundhay, Leeds.

1896. ‡Holland, Mrs. Lowfields House, Hooton.

1898. ‡Holland, Thomas H., F.G.S. Geological Survey Office, Calcutta.

1889. ‡Holländer, Bernard, M.D. King's College, Strand, W.C.

Year of Election.

1886. ‡Holliday, J. R. 101 Harborne-road, Birmingham.
1883. ‡Hollingsworth, Dr. T. S. Elford Lodge, Spring Grove, Isleworth.
1883. *Holmes, Mrs. Basil. 5 Freeland-road, Ealing, Middlesex, W.
1866. *Holmes, Charles. 24 Aberdare-gardens, West Hampstead, N.W.
1892. ‡Holmes, Matthew. Netherby, Lenzie, Scotland.
1882. *HOLMES, THOMAS VINCENT, F.G.S. 28 Croom's-hill, Greenwich, S.E.
1896. ‡Holt, William Henry. 11 Ashville-road, Birkenhead.
1897. ‡Holterman, R. F. Brantford, Ontario, Canada.
1875. *Hood, John. Chesterton, Cirencester.
1847. ‡HOOKER, Sir JOSEPH DALTON, G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., F.R.G.S. (PRESIDENT, 1868; Pres. E, 1881; Council 1866–67). The Camp, Sunningdale, Berkshire.
1892. ‡HOOKER, REGINALD H., M.A. 3 Gray's Inn-place, W.C.
1865. *Hooper, John P. Deepdene, Streatham Common, S.W.
1877. *Hooper, Rev. Samuel F., M.A. Lydlinch Rectory, Sturminster Newton, Dorset.
1901. *Hopkinson, Bertram, M.A. Holmwood, Wimbledon.
1884. *HOPKINSON, CHARLES (Local Sec. 1887). The Limes, Didsbury, near Manchester.
1882. *Hopkinson, Edward, M.A., D.Sc. Oakleigh, Timperley, Cheshire.
1871. *HOPKINSON, JOHN, Assoc.M.Inst.C.E., F.L.S., F.G.S., F.R.Met.Soc. 84 New Bond-street, W.; and Weetwood, Watford.
1858. ‡Hopkinson, Joseph, jun. Britannia Works, Huddersfield.
1891. ‡Horder, T. Garrett. 10 Windsor-place, Cardiff.
1898. *Hornby, R., M.A. Haileybury College, Hertford.
1885. ‡HORNE, JOHN, LL.D., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1901). Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1902. §Horner, John. Chelsea, Antrim-road, Belfast.
1875. *Horniman, F. J., M.P., F.R.G.S., F.L.S. Falmouth House, 20 Hyde Park-terrace, W.
1884. *Horsfall, Richard. Stoodley House, Halifax.
1887. ‡Horsfall, T. C. Swanscoe Park, near Macclesfield.
1893. *HORSLEY, Sir VICTOR A. H., B.Sc., F.R.S., F.R.C.S. (Council 1893–98.) 25 Cavendish-square, W.
1884. *Hotblack. G. S. Brundall, Norwich.
1899. ‡Hotblack, J. T. 45 Newmarket-road, Norwich.
1859. ‡Hough, Joseph, M.A., F.R.A.S. Codsall Wood, Wolverhampton.
1896. *Hough, S. S., F.R.S. Royal Observatory, Cape Town.
1886. ‡Houghton, F. T. S., M.A., F.G.S. 188 Hagley-road, Edgbaston, Birmingham.
1887. ‡Houldsworth, Sir W. H., Bart., M.P. Norbury Booths, Knutsford.
1896. ‡Hoult, J. South Castle-street, Liverpool.
1884. ‡Houston, William. Legislative Library, Toronto, Canada.
1883. *Hovenden, Frederick, F.L.S., F.G.S. Glenlea, Thurlow Park-road, West Dulwich, Surrey, S.E.
1893. ‡Howard, F. T., M.A., F.G.S. The Cottage, Poynton, Stockport.
1883. ‡Howard, James Fielden, M.D., M.R.C.S. Sandycroft, Shaw.
1887. *Howard, S. S. 58 Albemarle-road, Beckenham, Kent.
1899. §Howard-Hayward, H. Harbledown, 120 Queen's-road, Richmond, Surrey.
1901. §Howarth, E. Public Museum, Weston Park, Sheffield.
1886. ‡Howatt, David. 3 Birmingham-road, Dudley.
1876. ‡Howatt, James. 146 Buchanan-street, Glasgow.
1899. ‡Howden, Ian D. C. 6 Cambridge-terrace, Dover.
1889. ‡Howden, Robert, M.B., Professor of Anatomy in the University of Durham College of Medicine, Newcastle-upon-Tyne.

Year of Election.

1857. ‡Howell, Henry H., F.G.S. 13 Cobden-crescent, Edinburgh.
1898. ‡Howell, J. H. 104 Pembroke-road, Clifton, Bristol.
1891. ‡Howell, Rev. William Charles, M.A. Holy Trinity Parsonage, High Cross, Tottenham, Middlesex.
1886. §HOWES, G. B., LL.D., D.Sc., F.R.S., F.L.S. (Pres. D, 1902; Council, 1902–), Professor of Zoology in the Royal College of Science, South Kensington, S.W.
1901. §Howie, Robert Y. 41 Mill-road, Paisley.
1884. ‡Howland, Edward P., M.D. 211 41½-street, Washington, U.S.A.
1884. ‡Howland, Oliver Aiken. Toronto, Canada.
1865. *HOWLETT, Rev. FREDERICK, F.R.A.S. 7 Prince's-buildings, Clifton, Bristol.
1863. ‡HOWORTH, Sir H. H., K.C.I.E., M.P., D.C.L., F.R.S., F.S.A. 30 Collingham-place, Cromwell-road, S.W.
1883. ‡Howorth, John, J.P. Springbank, Burnley, Lancashire.
1883. ‡Hoyle, James. Blackburn.
1887. §HOYLE, WILLIAM E., M.A. Owens College, Manchester.
1888. ‡Hudd, Alfred E., F.S.A. Clinton House, Pembroke-road, Clifton, Bristol.
1898. §HUDLESTON, W. H., M.A., F.R.S., F.G.S. (Pres. C, 1898). 8 Stanhope-gardens, S.W.
1888. ‡HUDSON, C. T., M.A., LL.D., F.R.S. Hillside, Clarence-road, Shanklin, Isle of Wight.
1902. *Hudson, R. W. H. T., M.A. St. John's College, Cambridge.
1867. *HUDSON, WILLIAM H. H., M.A., Professor of Mathematics in King's College, London. 15 Altenberg-gardens, Clapham Common, S.W.
1858. *HUGGINS, Sir WILLIAM, K.C.B., D.C.L. Oxon., LL.D. Camb., Pres.R.S., F.R.A.S. (PRESIDENT, 1891; Council, 1868–74, 1876–84). 90 Upper Tulse-hill, S.W.
1887. ‡Hughes, E. G. 4 Roman-place, Higher Broughton, Manchester
1883. ‡Hughes, Miss E. P. Cambridge Teachers' College, Cambridge.
1871. *Hughes, George Pringle, J.P. Middleton Hall, Wooler, Northumberland.
1887. ‡Hughes, John Taylor. Thorleymoor, Ashley-road, Altrincham.
1896. ‡Hughes, John W. New Heys, Allerton, Liverpool.
1891. ‡Hughes, Thomas, F.C.S. 31 Loudoun-square, Cardiff.
1868. §HUGHES, T. M'K., M.A., F.R.S., F.G.S., Woodwardian Professor of Geology in the University of Cambridge. Ravensworth, Brooklands-avenue, Cambridge.
1891. ‡Hughes, Rev. W. Hawker. Jesus College, Oxford.
1897. ‡Hume, J. G., M.A., Ph.D. 650 Church-street, Toronto, Canada.
1901. §Hume, John H. 63 Bridgegate, Irvine.
1890 ‡Humphrey, Frank W. 63 Prince's-gate, S.W.
1878. ‡Humphreys, H. Castle-square, Carnarvon.
1880. ‡Humphreys, Noel A., F.S.S. Ravenhurst, Hook, Kingston-on-Thames.
1877. *HUNT, ARTHUR ROOPE, M.A., F.G.S. Southwood, Torquay.
1891. *Hunt, Cecil Arthur. Southwood, Torquay.
1886. ‡Hunt, Charles. The Gas Works, Windsor-street, Birmingham.
1891. ‡Hunt, D. de Vere, M.D. Aubrey House, Cathedral-road, Cardiff.
1875. *Hunt, William. North Cote, Westbury-on-Trym, Bristol.
1881. ‡Hunter, F. W. Newbottle, Fence Houses, Co. Durham.
1889. ‡Hunter, Mrs. F. W. Newbottle, Fence Houses, Co. Durham.
1901. ‡Hunter, G. M., Assoc.M.Inst.C.E. Newyards, Maybole, N.B.
1881. ‡Hunter, Rev. John. University-gardens, Glasgow.
1884. *Hunter, Michael. Greystones, Sheffield.

Year of Election.

1901. *Hunter, William. Evirallan, Stirling.
1879. ‡HUNTINGTON, A. K., F.C.S., Professor of Metallurgy in King's College, W.C.
1885. ‡Huntly, The Most Hon. the Marquess of. Aboyne Castle, Aberdeenshire.
1863. ‡Huntsman, Benjamin. West Retford Hall, Retford.
1898. ‡Hurle, J. Cooke. Southfield House, Brislington, Bristol.
1882. *Hurst, Walter, B.Sc. Kirkgate, Tadcaster, Yorkshire.
1861. *Hurst, William John. Drumaness, Ballynahinch, Co. Down, Ireland.
1894. *Hutchinson, A. Pembroke College, Cambridge.
Hutton, Crompton. Harescombe Grange, Stroud, Gloucestershire.
1864. *Hutton, Darnton. 14 Cumberland-terrace, Regent's Park, N.W.
1887. *Hutton, J. Arthur. The Woodlands, Alderley Edge, Cheshire.
1901. *Hutton, R. S., M.Sc. The Owens College, Manchester.
1883. ‡Hyde, George H. 23 Arbour-street, Southport.
1871. *Hyett, Francis A. Painswick House, Painswick, Stroud, Gloucestershire.
1900. *Hyndman, H. H. Francis. Physical Laboratory, Leiden, Netherlands.
1902. §Hyndman, Hugh. Crosshill, Windsor-avenue, Belfast.

1883. §Idris, T. H. W. Pratt-street, Camden Town, N.W.
Ihne, William, Ph.D. Heidelberg.
1884. *Iles, George. 5 Brunswick-street, Montreal, Canada.
1885. ‡im-Thurn, Everard F., C.B., C.M.G., M.A. 23 Edwardes-square, Kensington, W.
1888. *Ince, Surgeon-Lieut.-Col. John, M.D. Montague House, Swanley, Kent.
1858. ‡Ingham, Henry. Wortley, near Leeds.
1893. ‡*Ingle, Herbert. Pool, Leeds.*
1901. §INGLIS, JOHN, LL.D. 4 Prince's-terrace, Dowanhill, Glasgow.
1891. ‡Ingram, Lieut.-Colonel C. W. Bradford-place, Penarth.
1852. ‡INGRAM, J. K., LL.D., M.R.I.A., Senior Lecturer in the University of Dublin. 2 Wellington-road, Dublin.
1885. ‡Ingram, William, M.A. Gamrie, Banff.
1886. ‡*Innes, John. The Limes, Alcester Road, Moseley, Birmingham.*
1898. ‡Inskip, James. Clifton Park, Clifton, Bristol.
1901. *Ionides, Stephen. 23 Second-avenue, Hove, Brighton.
1892. ‡*Ireland, D. W. 10 South Gray Street, Edinburgh.*
1892. ‡Irvine, James. Devonshire-road, Birkenhead.
1882. §IRVING, Rev. A., B.A., D.Sc. Hockerill Vicarage, Bishop's Stortford, Herts.

1859. ‡Jack, John, M.A. Belhelvie-by-Whitecairns, Aberdeenshire.
1884. ‡Jack, Peter. People's Bank, Halifax, Nova Scotia, Canada.
1876. *JACK, WILLIAM, LL.D., Professor of Mathematics in the University of Glasgow. 10 The College, Glasgow.
1901. §Jacks, William, LL.D. Crosslet, Dumbartonshire.
1883. *JACKSON, Professor A. H., B.Sc. 358 Collins-street, Melbourne, Australia.
1874. *Jackson, Frederick Arthur. Penalva Ranche, Millarville, Alberta, Calgary, N.W.T., Canada.
1883. *Jackson, F. J. 35 Leyland-road, Southport.
1883. ‡Jackson, Mrs. F. J. 35 Leyland-road, Southport.
1899. §Jackson, Geoffrey A. 31 Harrington-gardens, Kensington, S.W.

Year of
Election.
1866. ‡Jackson, H. W., F.R.A.S. 67 Upgate, Louth, Lincolnshire.
1897. §Jackson, James, F.R.Met.Soc. The Avenue, Girvan, N.B.
1898. *Jackson, Sir John. 3 Victoria-street, S.W.
1869. §Jackson, Moses, J.P. The Orchards, Whitchurch, Hants.
1887. §Jacobson, Nathaniel. Olive Mount, Cheetham Hill-road, Manchester.
1874. *Jaffe, John. Villa Jaffe, 38 Prom. des Anglais, Nice, France.
1891. ‡James, Arthur P. Grove House, Park-grove, Cardiff.
1891. *James, Charles Henry. 64 Park-place, Cardiff.
1891. **James, Charles Russell.* *6 New-court, Lincoln's Inn, W.C.*
1860. ‡James, Edward H. Woodside, Plymouth.
1886. ‡*James, Frank.* *Portland House, Aldridge, near Walsall.*
1891. ‡James, Ivor. University College, Cardiff.
1891. ‡James, J. R., L.R.C.P. 158 Cowbridge-road, Canton, Cardiff.
1896. ‡James, O. S. 192 Jarvis-street, Toronto, Canada.
1858. ‡James, William C. Woodside, Plymouth.
1896. *Jameson, H. Lyster, M.A., Ph.D. Technical College, Derby.
1884. ‡Jameson, W. C. 48 Baker-street, Portman-square, W.
1881. ‡Jamieson, Andrew, Principal of the College of Science and Arts, Glasgow.
1885. ‡Jamieson, Thomas. 173 Union-street, Aberdeen.
1859. *Jamieson, Thomas F., LL.D., F.G.S. Ellon, Aberdeenshire.
1889. *JAPP, F. R., M.A., Ph.D., LL.D., F.R.S. (Pres. B, 1898), Professor of Chemistry in the University of Aberdeen.
1896. *Jarmay, Gustav. Hartford Lodge, Hartford, Cheshire.
1870. ‡Jarrold, John James. London-street, Norwich.
1891. ‡Jefferies, Henry. Plas Newydd, Park-road, Penarth.
1855. *Jeffray, John. 9 Winton-drive, Kelvinside, Glasgow.
1897. ‡Jeffrey, E. C., B.A. The University, Toronto, Canada.
1867. ‡*Jeffreys, Howel, M.A.* 61 *Bedford-gardens, Kensington, W.*
1894. ‡Jelly, Dr. W. Aveleanas, 11, Valencia, Spain.
1891. §Jenkins, Henry C., Assoc.M.Inst.C.E., F.C.S. Royal College of Science, South Kensington, S.W.
1873. §Jenkins, Major-General J. J. 16 St. James's-square, S.W.
1880. *JENKINS, Sir JOHN JONES. The Grange, Swansea.
1899. §Jenkins, Colonel T. M. Glan Tivy, Westwood-road, Southampton.
1852. ‡Jennings, Francis M., M.R.I.A. Brown-street, Cork.
1893. §Jennings, G. E. Glen Helen, Narborough Road, Leicester.
1897. ‡Jennings, W. T., M.Inst.CE. Molson's Bank Buildings, Toronto, Canada.
1899. ‡Jepson, Thomas. Evington, Northumberland-street, Higher Broughton, Manchester.
1887. ‡JERVIS-SMITH, Rev. F. J., M.A , F.R.S. Trinity College, Oxford.
Jessop, William. Overton Hall, Ashover, Chesterfield.
1889. ‡Jevons, F. B., M.A. The Castle, Durham.
1900. *Jevons, H. Stanley. 19 Chesterfield-gardens, Hampstead, N.W.
1884. ‡Jewell, Lieutenant Theo. F. Torpedo Station, Newport, Rhode Island, U.S.A.
1884. ‡Johns, Thomas W. Yarmouth, Nova Scotia, Canada.
1884. ‡JOHNSON, ALEXANDER, M.A., LL.D., Professor of Mathematics in McGill University, Montreal. 5 Prince of Wales-terrace, Montreal, Canada.
1883. ‡Johnson, Miss Alice. Llandaff House, Cambridge.
1865. *Johnson, G. J. 36 Waterloo-street, Birmingham.
1888. ‡Johnson, J. G. Southwood Court, Highgate, N.
1870. ‡*Johnson, Richard C., F.R.A.S.* 46 *Jermyn-street, Liverpool.*
1863. ‡Johnson, R. S. Hanwell, Fence Houses, Durham.

Year of Election.

1881. ‡Johnson, Sir Samuel George. Municipal Offices, Nottingham.

1890. *JOHNSON, THOMAS, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, Dublin.

1902. *Johnson, Rev. W., B.A., B.Sc. Archbishop Holgate's Grammar School, York.

1898. *Johnson, W. Claude, M.Inst.C.E. The Dignaries, Blackheath, S.E.

1887. ‡Johnson, W. H. Woodleigh, Altrincham, Cheshire.

1883. ‡Johnson, W. H. F. Llandaff House, Cambridge.

1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham, Cheshire.

1899. §Johnston, Colonel Duncan A., R.E. Ordnance Survey, Southampton.

1883. ‡JOHNSTON, Sir H. H., G.C.M.G., K.C.B., F.R.G.S. Queen Anne's-mansions, S.W.

1884. ‡Johnston, John L. 27 St. Peter-street, Montreal, Canada.

1883 ‡Johnston, Thomas. Broomsleigh, Seal, Sevenoaks.

1884. ‡Johnston, Walter R. Fort Qu'Appelle, N.W. Territory, Canada.

1884. *Johnston, W. H. County Offices, Preston, Lancashire.

1885. ‡JOHNSTON-LAVIS, H. J., M.D., F.G.S. Beaulieu, Alpes Maritimes, France.

1886. ‡Johnstone, G. H. Northampton-street, Birmingham.

1871. ‡JOLLY, WILLIAM, F.R.S.E., F.G.S. Blantyre Lodge, Blantyre, N.B.

1888. ‡Jolly, W. C. Home Lea, Lansdowne, Bath.

1896. *JOLY, C. J., M.A. The Observatory, Dunsink, Co. Dublin.

1888. ‡JOLY, JOHN, M.A., D.Sc., F.R.S., F.G.S., Professor of Geology and Mineralogy in the University of Dublin.

1898. ‡Jones, Sir Alfred L., K.C.M.G. Care of Messrs. Elder, Dempster, & Co., Liverpool.

1887. ‡Jones, D. E., B.Sc., H.M. Inspector of Schools. Science and Art Department, South Kensington, S.W.

1890. §JONES, Rev. EDWARD, F.G.S. Primrose Cottage, Embsay, Skipton.

1891. ‡Jones, Dr. Evan. Aberdare.

1896. ‡Jones, E. Taylor, D.Sc. University College, Bangor.

1887. ‡Jones, Francis, F.R.S.E., F.C.S. Beaufort House, Alexandra Park, Manchester.

1891. *JONES, Rev. G. HARTWELL, M.A. Nutfield Rectory, Redhill, Surrey.

1883. *Jones, George Oliver, M.A. Inchyra House, 21 Cambridge-road, Waterloo, Liverpool.

1895. ‡Jones, Harry. Engineer's Office, Great Eastern Railway, Ipswich.

1877. ‡Jones, Henry C., F.C.S. Royal College of Science, South Kensington, S.W.

1901. §Jones, R. E., J.P. Radnor House, Shrewsbury.

1902. §Jones, R. M., M.A. Royal Academical Institution, Belfast.

1873. ‡Jones, Theodore B. 1 Finsbury-circus, E.C.

1880. ‡Jones, Thomas. 15 Gower-street, Swansea.

1860. ‡JONES, THOMAS RUPERT, F.R.S., F.G.S. (Pres. C, 1891). 17 Parson's Green, Fulham, S.W.

1896. ‡Jones, W. Hope Bank, Lancaster-road, Pendleton, Manchester.

1883. ‡Jones, William. Elsinore, Birkdale, Southport.

1875. *Jose, J. E. 49 Whitechapel, Liverpool.

1884. ‡Joseph, J. H. 738 Dorchester-street, Montreal, Canada.

1891. ‡Jotham, F. H. Penarth.

1891. ‡Jotham, T. W. Penylan, Cardiff.

1879. ‡Jowitt, A. Scotia Works, Sheffield.

1890. ‡Jowitt, Benson R. Elmhurst, Newton-road, Leeds.

1872. ‡Joy, Algernon. Junior United Service Club, St. James's, S.W.

1883. ‡Joyce, Rev. A. G., B.A. St. John's Croft, Winchester.

1886. ‡Joyce, The Hon. Mrs. St. John's Croft, Winchester.

Year of
Election.

1891. ‡Joynes, John J. Great Western Colliery, near Coleford, Gloucestershire.
1848. **Jubb, Abraham. Halifax.*
1870. ‡JUDD, JOHN WESLEY, C.B., LL.D., F.R.S., F.G.S. (Pres. C, 1885; Council, 1886–92), Professor of Geology in the Royal College of Science, London. 22 Cumberland-road, Kew.
1894. §Julian, Mrs. Forbes. Redholme, Braddon's Hill-road, Torquay.
1883. ‡Justice, Philip Middleton. 14 Southampton-buildings, Chancery-lane, W.C.

1888. ‡Kapp, Gisbert, M.Inst.C.E., M.Inst.E.E. 3 Lindenallee, Westend, Berlin.
1884. ‡Keefer, Samuel. Brockville, Ontario, Canada.
1875. ‡Keeling, George William. Tuthill, Lydney.
1886. ‡Keen, Arthur, J.P. Sandyford, Augustus-road, Birmingham.
1894. ‡*Keightley, Rev. G. W. Great Stambridge Rectory, Rochford, Essex.*
1878. *Kelland, W. H. North Street, Exeter.
1884. ‡Kellogg, J. H., M.D. Battle Creek, Michigan, U.S.A.
1864. *Kelly, W. M., M.D. Ferring, near Worthing.
1902. *Kelly, William J., J.P. Oxford-street, Belfast.
1885. §KELTIE, J. SCOTT, LL.D., Sec. R.G.S., F.S.S. (Pres. E, 1897; Council, 1898–). 1 Savile-row, W.
1847. *KELVIN, The Right Hon. Lord, G.C V.O., M.A., LL.D., D.C.L., F.R.S., F.R.S.E., F.R.A.S. (PRESIDENT, 1871; Pres. A, 1852, 1867, 1876, 1881, 1884). Netherhall, Largs, Ayrshire.
1877. *Kelvin, Lady. Netherhall, Largs, Ayrshire.
1887. ‡Kemp, Harry. 55 Wilbraham-road, Chorlton-cum-Hardy, Manchester.
1898. *Kemp, John T., M.A. 4 Cotham-grove, Bristol.
1884. ‡Kemper, Andrew C., A.M., M.D. 101 Broadway, Cincinnati, U.S.A.
1890. ‡Kempson, Augustus. Kildare, 17 Arundel-road, Eastbourne.
1891. §KENDALL, PERCY F., F.G.S., Professor of Geology in Yorkshire College, Leeds.
1875. ‡KENNEDY, ALEXANDER B. W., LL.D., F.R.S., M.Inst.C.E. (Pres. G, 1894). 17 Victoria-street, S.W., and 1 Queen Anne-street, Cavendish-square, W.
1897. §Kennedy, George, M.A., LL.D. Crown Lands Department, Toronto, Canada.
1884. ‡Kennedy, George T., M.A., F.G.S., Professor of Chemistry and Geology in King's College, Windsor, Nova Scotia, Canada.
1876. ‡Kennedy, Hugh. 20 Mirkland-street, Glasgow.
1884. ‡Kennedy, John. 113 University-street, Montreal, Canada.
1884. ‡Kennedy, William. Hamilton, Ontario, Canada.
1886. ‡Kenrick, George Hamilton. Whetstone, Somerset-road, Edgbaston, Birmingham.
1893. §KENT, A. F. STANLEY, M.A., F.L.S., F.G.S., Professor of Physiology in University College, Bristol.
1901. §Kent, G. 16 Premier-road, Nottingham.
1886. §KENWARD, JAMES, F.S.A. 43 Streatham High-road, S.W.
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1876. ‡Ker, William. 1 Windsor-terrace West, Glasgow.
1881. ‡KERMODE, PHILIP M. C. Hillside, Ramsey, Isle of Man.
1884. ‡Kerr, James, M.D. Winnipeg, Canada.
1883. ‡KERR, REV. JOHN, LL.D., F.R.S. Free Church Training College, 113 Hill-street, Glasgow.

Year of Election.

1901. ‡Kerr, John G., LL.D. 15 India-street, Glasgow.
1892. ‡Kerr, J. Graham, M.A., Professor of Natural History in the University, Glasgow.
1889. ‡Kerry, W. H. R. The Sycamores, Windermere.
1887. ‡Kershaw, James. Holly House, Bury New-road, Manchester.
1869. *Kesselmeyer, Charles Augustus. Rose Villa, Vale-road, Bowdon, Cheshire.
1869. *Kesselmeyer, William Johannes. Elysée Villa, Manchester-road, Altrincham, Cheshire.
1883. *Keynes, J. N., M.A., D.Sc., F.S.S. 6 Harvey-road, Cambridge.
1902. §Kidd, George. Dunmurry, Co. Antrim.
1876. ‡Kidston, J. B. 50 West Regent-street, Glasgow.
1886. §KIDSTON, ROBERT, F.R.S., F.R.S.E., F.G.S. 12 Clarendon-place, Stirling.
1897. ‡Kiekelly, Dr. John, LL.D. 46 Upper Mount-street, Dublin.
1901. §Kiep, J. N. 4 Hughenden-drive, Kelvinside, Glasgow.
1885. *Kilgour, Alexander. Loirston House, Cove, near Aberdeen.
1896. *Killey, George Deane. Bentuther, 11 Victoria-road, Waterloo, Liverpool.
1890. §KIMMINS, C. W., M.A., D.Sc. Bermondsey Settlement Lodge, Farncombe-street, S.E.
1878. ‡Kinahan, Sir Edward Hudson, Bart. 11 Merrion-square North, Dublin.
1860. ‡KINAHAN, G. HENRY, M.R.I.A. Dublin.
1875. *KINCH, EDWARD, F.C.S. Royal Agricultural College, Cirencester.
1888. ‡King, Austin J. Winsley Hill, Limpley Stoke, Bath.
1888. *King, E. Powell. Wainsford, Lymington, Hants.
1875. *King, F. Ambrose. Avonside, Clifton, Bristol.
1899. ‡KING, Sir GEORGE, K.C.I.E., F.R.S. (Pres. K, 1899). Care of Messrs. Grindlay & Co., 55 Parliament-street, S.W.
1871. *King, Rev. Herbert Poole. The Rectory, Stourton, Bath.
1855. ‡King, James. Levernholme, Hurlet, Glasgow.
1883. *King, John Godwin. Stonelands, West Hoathley.
1870. ‡King, John Thomson. 4 Clayton-square, Liverpool.
1883. *King, Joseph. Lower Birtley, Witley, Godalming.
1860. *King, Mervyn Kersteman. Merchants' Hall, Bristol.
1875. *King, Percy L. 2 Worcester-avenue, Clifton, Bristol.
1901. ‡King, Robert. Levernholme, Nitshill, Glasgow.
1870. ‡King, William. 5 Beach Lawn, Waterloo, Liverpool.
1897. ‡Kingsmill, Nichol. Toronto, Canada.
1875. ‡KINGZETT, CHARLES T., F.C.S. Elmstead Knoll, Chislehurst.
1867. ‡Kinloch, Colonel. Kirriemuir, Logie, Scotland.
1892. ‡Kinnear, The Hon. Lord, F.R.S.E. 2 Moray-place, Edinburgh.
1900. ‡KIPPING, Professor F. STANLEY, D.Sc., Ph.D., F.R.S. University College, Nottingham.
1899. *Kirby, Miss C. F. 74 Kensington Park-road, W.
1899. *Kirby, Miss M. A. Field House, Richmond-road, Montpelier, Bristol.
1870. ‡Kitchener, Frank E. Newcastle, Staffordshire.
1890. *KITSON, Sir JAMES, Bart., M.P. Gledhow Hall, Leeds.
1901. §Kitto, Edward. The Observatory, Falmouth.
1886. ‡Klein, Rev. L. M. de Beaumont, D.Sc., F.L.S. 6 Devonshire-road, Liverpool.
1886. ‡Knight, J. McK., F.G.S. Bushwood, Wanstead, Essex.
1898. ‡KNOCKER, Sir E. WOLLASTON, K.C.B. (Local Sec. 1899). Castle Hill House, Dover.
1888. ‡KNOTT, Professor CARGILL G., D.Sc., F.R.S.E. 42 Upper Gray-street, Edinburgh.

Year of Election.

1887. *Knott, Herbert. Aingarth, Stalybridge, Cheshire.
1887. *Knott, John F. Glan-y-Coed, Conway.
1874. ‡Knowles, William James. Flixton-place, Ballymena, Co. Antrim.
1897. ‡Knowlton, W. H. 36 King-street East, Toronto, Canada.
1876. ‡Knox, David N., M.A., M.B. 24 Elmbank-crescent, Glasgow.
1902. §KNOX, R. KYLE, LL.D. 1 College-gardens, Belfast.
1875. *Knubley, Rev. E. P., M.A. Steeple Ashton Vicarage, Trowbridge.
1883. ‡Knubley, Mrs. Steeple Ashton Vicarage, Trowbridge.
1892. ‡KOHN, CHARLES A., Ph.D. Sir John Cass Technical Institute, Aldgate, E.
1898. ‡Krauss, A. Hawthornden, Priory-road, Clifton, Bristol.
1890. *Krauss, John Samuel, B.A. Hodnet, Salop.
1901. ‡Kuenen, Professor J. P., Ph.D. University College, Dundee.
1888. *Kunz, G. F. Care of Messrs. Tiffany & Co., 11 Union-square, New York City, U.S.A.
1870. ‡Kynaston, Josiah W., F.C.S. 3 Oak-terrace, Beech-street, Liverpool.

1858. ‡Lace, Francis John. Stone Gapp, Cross Hill, Leeds.
1884. ‡Laflamme, Rev. Professor J. C. K. Laval University, Quebec.
1885. *Laing, J. Gerard. 2 Brick-court, Temple, E.C.
1897. ‡Laird, Professor G. J. Wesley College, Winnipeg, Canada.
1877. ‡Lake, W. C., M.D. Teignmouth.
1859. ‡Lalor, John Joseph, M.R.I.A. City Hall, Cork Hill, Dublin.
1889. *Lamb, Edmund, M.A. Borden Wood, Liphook, Hants.
1887. ‡LAMB, HORACE, M.A., F.R.S., Professor of Pure Mathematics in the Owens College, Manchester. 6 Wilbraham-road, Fallowfield, Manchester.
1887. ‡Lamb, James. Kenwood, Bowdon, Cheshire.
1896. ‡Lambert, Frederick Samuel. Balgowan, Newland, Lincoln.
1893. ‡Lambert, J. W., J.P. Lenton Firs, Nottingham.
1884. ‡Lamborn, Robert H. Montreal, Canada.
1893. ‡LAMPLUGH, G. W., F.G.S. Geological Survey Office, 14 Hume-street, Dublin.
1890. ‡Lamport, Edward Parke. Greenfield Well, Lancaster.
1884. ‡*Lancaster, Alfred. Fern Bank, Burnley, Lancashire.*
1871. ‡Lancaster, Edward. Karesforth Hall, Barnsley, Yorkshire.
1886. ‡Lancaster, W. J., F.G.S. Colmore-row, Birmingham.
1877. ‡Landon, Frederic George, M.A., F.R.A.S. 59 Tresillian-road, St. John's, S.E.
1883. ‡Lang, Rev. Gavin. Mayfield, Inverness.
1859. ‡Lang, Rev. John Marshall, D.D. The University, Aberdeen.
1898. *Lang, William H. 10 Jedburgh-gardens, Kelvinside, Glasgow.
1886. *LANGLEY, J. N., M.A., D.Sc., F.R.S. (Pres. I, 1899). Trinity College, Cambridge.
1870. ‡Langton, Charles. Barkhill, Aigburth, Liverpool.
1865. ‡LANKESTER, E. RAY, M.A., LL.D., F.R.S. (Pres. D, 1883; Council 1889–90, 1894–95, 1900–02), Director of the Natural History Museum, Cromwell-road, S.W.
1880. *LANSDELL, Rev. HENRY, D.D., F.R.A.S., F.R.G.S. Morden College, Blackheath, London, S.E.
1884. §Lanza, Professor G. Massachusetts Institute of Technology, Boston, U.S.A.
1878. ‡Lapper, E., M.D. 61 Harcourt-street, Dublin.
1885. ‡LAPWORTH, CHARLES, LL.D., F.R.S., F.G.S. (Pres. C, 1892), Professor of Geology and Physiography in the University, Birmingham. 48 Frederick-road, Edgbaston, Birmingham.

Year of Election.

1887. ‡Larmor, Alexander. Craglands, Helen's Bay, Co. Down.
1881. ‡LARMOR, JOSEPH, M.A., D.Sc., Sec.R.S. (Pres. A, 1900). St. John's College, Cambridge.
1883. §Lascelles, B. P., M.A. Longridge, Harrow.
1896. *Last, William J. South Kensington Museum, London, S.W.
1870. *LATHAM, BALDWIN, M.Inst.C.E., F.G.S. 7 Westminster-chambers, Westminster, S.W.
1900. ‡Lauder, Alexander. University College, Bangor.
1870. ‡Laughton, John Knox, M.A., F.R.G.S. 5 Pepys-road, Wimbledon, Surrey.
1891. ‡Laurie, A. P. Heriot Watt College, Edinburgh.
1892. §LAURIE, MALCOLM, B.A., D.Sc., F.L.S., Professor of Zoology in St. Mungo's College, Glasgow.
1888. ‡Laurie, Colonel R. P., C.B. 79 Farringdon-street, E.C.
1883. ‡Laurie, Major-General. Oakfield, Nova Scotia, Canada.
1870. *Law, Channell. Ilsham Dene, Torquay.
1878. ‡Law, Henry, M.Inst.C.E. 9 Victoria-chambers, S.W.
1884. §Law, Robert, F.G.S. Fennyroyd Hall, Hipperholme, near Halifax, Yorkshire
1870. ‡Lawrence, Edward. Aigburth, Liverpool.
1881. ‡Lawrence, Rev. F., B.A. The Vicarage, Westow, York.
1900. ‡Lawrence, W. Trevor, Ph.D. 57 Prince's-gate, S.W.
1889. §Laws, W. G., M.Inst.C.E. 95 Osborne-road, Newcastle-upon-Tyne.
1885. ‡Lawson, James. 8 Church-street, Huntly, N.B.
1888. §Layard, Miss Nina F. Rookwood, Ipswich.
1856. ‡Lea, Henry. 38 Bennett's-hill, Birmingham.
1883. *Leach, Charles Catterall. Seghill, Northumberland.
1875. ‡Leach, Colonel Sir G., K.C.B., R.E. 6 Wetherby-gardens, S.W.
1894. *LEAHY, A. H., M.A., Professor of Mathematics in University College. 92 Ashdell-road, Sheffield.
1884. *Leahy, John White, J.P. South Hill, Killarney, Ireland.
1901. *Lean, George, B.Sc. 15 Park-terrace, Glasgow.
1884. ‡Learmont, Joseph B. 120 Mackay-street, Montreal, Canada.
1884. *Leavitt, Erasmus Darwin. 2 Central-square, Cambridgeport, Massachusetts, U.S.A.
1872. ‡LEBOUR, G. A., M.A., F.G.S., Professor of Geology in the Durham College of Science, Newcastle-on-Tyne.
1884. ‡Leckie, R. G. Springhill, Cumberland County, Nova Scotia, Canada.
1895. *Ledger, Rev. Edmund. Proted, Woods-road, Reigate.
1898. §LEE, ARTHUR, J.P. (Local Sec. 1898). 10 Berkeley-square, Clifton, Bristol.
1896. §Lee, Rev. H. J. Barton. 35 Cross Park-terrace, Heavitree, Exeter.
1891. ‡*Lee, Mark. The Cedars, Llandaff-road, Cardiff.*
1894. *Lee, Mrs. W. Ashdown House, Forest Row, Sussex.
1884. *Leech, Sir Bosdin T. Oak Mount, Timperley, Cheshire.
1896. *Leech, Lady. Oak Mount, Timperley, Cheshire.
1892. *LEES, CHARLES H., D.Sc. 42 Lorne-grove, Fallowfield, Manchester.
1886. *Lees, Lawrence W. Old Ivy House, Tettenhall, Wolverhampton
1859. ‡Lees, William, M.A. 12 Morningside-place, Edinburgh.
1896. ‡Lees, William. 10 Norfolk-street, Manchester.
*Leese, Joseph. 3 Lord-street West, Southport.
1889. *Leeson, John Rudd, M.D., C.M., F.L.S., F.G.S. Clifden House, Twickenham, Middlesex.
1881. ‡LE FEUVRE, J. E. (Local Sec. 1882). Southampton.
1872. ‡LEFEVRE, The Right Hon. G. SHAW, F.R.S. (Pres. F, 1879; Council 1878–80). 18 Bryanston-square, W.
1869. ‡Le Grice, A. J. Trereife, Penzance.

Year of Election.

1892. ‡LEHFELDT, ROBERT A. 28 South Molton-street, W.
1868. ‡LEICESTER, The Right Hon. the Earl of, K.G. Holkham, Norfolk.
1856. ‡LEIGH, The Right Hon. Lord. Stoneleigh Abbey, Kenilworth.
1891. ‡Leigh, W. W. Treharris, R.S.O., Glamorganshire.
1859. ‡Leith, Alexander. Glenkindie, Inverkindie, N.B.
1882. §Lemon, James, M.Inst.C.E., F.G.S. Lansdowne House, Southampton.
1867. ‡Leng, Sir John, M.P. 'Advertiser' Office, Dundee.
1902. §Lennox, R. N. Rosebank, Hammersmith, W.
1878. ‡Lennon, Rev. Francis. The College, Maynooth, Ireland.
1887. *Leon, John T. Elmwood, Grove-road, Southsea.
1871. ‡LEONARD, HUGH, M.R.I.A. 24 Mount Merrion-avenue, Blackrock, Co. Dublin.
1901. §Leonard, J. H. Paradise House, Stoke Newington, N.
1884. ‡Lesage, Louis. City Hall, Montreal, Canada.
1890. *Lester, Joseph Henry. Royal Exchange, Manchester.
1883. ‡Lester, Thomas. Fir Bank, Penrith.
1880. †*Letcher, R. J. Lansdowne-terrace, Walters-road, Swansea.*
1900. §Letts, Professor E. A., D.Sc., F.R.S.E. Queen's College, Belfast.
1894. ‡Leudesdorf, Charles. Pembroke College, Oxford.
1896. ‡Lever, W. H. Port Sunlight, Cheshire.
1887. *Levinstein, Ivan. Hawkesmoor, Fallowfield, Manchester.
1890. ‡Levy, J. H. 11 Abbeville-road, Clapham Park, S.W.
1893. *LEWES, VIVIAN B., F.C.S. Professor of Chemistry in the Royal Naval College, Greenwich, S.E.
1879. ‡Lewin, Colonel, F.R.G.S. Garden Corner House, Chelsea Embankment, S.W.
1870. ‡LEWIS, ALFRED LIONEL. 54 Highbury-hill, N.
1891. ‡Lewis, D., J.P. 44 Park-place, Cardiff.
1891. §Lewis, Professor D. Morgan, M.A. University College, Aberystwyth.
1899. ‡Lewis, Professor E. P. University of California, Berkeley, U.S.A.
1897. ‡Lewis, Rev. J Pitt, M.A. Rossin House, Toronto, Canada.
1899. ‡Lewis, Thomas. 9 Hubert-terrace, Dover.
1891. ‡Lewis, W. 22 Duke-street, Cardiff.
1891. ‡Lewis, W. Henry. Bryn Rhos, Llanishen, Cardiff.
1884. *Lewis, Sir W. T., Bart. The Mardy, Aberdare.
1878. ‡Lincolne, William. Ely, Cambridgeshire.
1901. §Lindsay, Charles C., M.Inst.C.E. 217 West George-street, Glasgow.
1871. ‡Lindsay, Rev. T. M., M.A., D.D. Free Church College, Glasgow.
1898. §Lippincott, R. C. Cann. Over Court, Almondsbury, near Bristol.
1883. ‡Lisle, H. Claud. Nantwich.
1895. *LISTER, The Right Hon. Lord, F.R.C.S., D.C.L., F.R.S. (PRESIDENT, 1896). 12 Park-crescent, Portland-place, W.
1888. ‡LISTER, J. J., M.A., F.R.S. Leytonstone, Essex, N.E.
1861. *LIVEING, G. D., M.A., F.R.S. (Pres. B, 1882; Council 1888–95: Local Sec. 1862), Professor of Chemistry in the University of Cambridge. Newnham, Cambridge.
1876. *LIVERSIDGE, ARCHIBALD, M.A., F.R.S., F.C.S., F.G.S., F.R.G.S., Professor of Chemistry in the University of Sydney, N.S.W.
1902. §Llewellyn, Evan Working Men's Institute and Hall, Blaenavon.
1880. †LLEWELYN, Sir JOHN T. D., Bart., M.P. Penllegare, Swansea.
1865. ‡Lloyd, G. B., J.P. Edgbaston-grove, Birmingham.
1886. ‡Lloyd, J. Henry. Ferndale, Carpenter-road, Edgbaston, Birmingham.
1891. *LLOYD, R. J., M.A., D.Litt., F.R.S.E 49A Grove-street, Liverpool.
1886. ‡Lloyd, Samuel. Farm, Sparkbrook, Birmingham.
1865. *Lloyd, Wilson, F.R.G.S. Park Lane House, Woodgreen, Wednesbury.

Year of Election.

1897. §Lloyd-Verney, J. H. 14 Hinde-street, Manchester-square, W.
1854. *LOBLEY, J. LOGAN, F.G.S. City of London College, Moorfields, E.C.
1892. §LOCH, C. S., B.A. 15A Buckingham-street, W.C.
1867. *Locke, John. 144 St. Olaf's-road, Fulham, S.W.
1892. ‡Lockhart, Robert Arthur. 10 Polwarth-terrace, Edinburgh.
1863. ‡LOCKYER, Sir J. NORMAN, K.C.B., F.R.S. (PRESIDENT-ELECT; Council 1871–76, 1901–02). 16 Penywern-road, S.W.
1900. §Lockyer, W. J. S., Ph.D. 16 Penywern-road, South Kensington, S.W.
1886. *LODGE, ALFRED, M.A., Professor of Pure Mathematics in the Royal Indian Civil Engineering College, Cooper's Hill. Englefield Green, Surrey.
1875. *LODGE, Sir OLIVER J., D.Sc., LL.D., F.R.S. (Pres. A, 1891; Council 1891–97, 1899–), Principal of the University of Birmingham.
1894. *Lodge, Oliver W. F. 225 Hagley-road, Birmingham.
1889. ‡Logan, William. Langley Park, Durham.
1896. §Lomas, J., F.G.S. 13 Moss-grove, Birkenhead.
1899. §Loncq, Emile. 6 Rue de la Plaine, Laon, Aisne, France.
1902. ‡LONDONDERRY, the Marquess of, K.G., H.M. Lieutenant of the City of Belfast. Londonderry House, Park-lane, W.
1876. ‡Long, H. A. Brisbane, Queensland.
1883. *Long, William. Thelwall Heys, near Warrington.
1883. ‡Long, Mrs. Thelwall Heys, near Warrington.
1883. ‡Long, Miss. Thelwall Heys, near Warrington.
1866. ‡Longdon, Frederick. Osmaston-road, Derby.
1901. ‡Longe, Francis D. The Alders, Marina, Lowestoft.
1898. *Longfield, Miss Gertrude. High Halstow Rectory, Rochester.
1901. *Longstaff, Frederick V., F.R.G.S. Clare College, Cambridge.
1875. *Longstaff, George Blundell, M.A., M.D., F.C.S., F.S.S. Highlands, Putney Heath, S.W.
1872. *Longstaff, Llewellyn Wood, F.R.G.S. Ridgelands, Wimbledon.
1881. *Longstaff, Mrs. Ll. W. Ridgelands, Wimbledon, Surrey.
1899. *Longstaff, Tom G., B.A., F.R.Met.Soc. Ridgelands, Wimbledon, Surrey.
1883. *Longton, E. J., M.D. Brown House, Blawith, *viâ* Ulverston.
1894. ‡Lord, Edwin C. E., Ph.D. 247 Washington-street, Brooklyn, U.S.A.
1889. ‡Lord, Sir Riley. 75 Pilgrim-street, Newcastle-upon-Tyne.
1897. ‡LOUDON, JAMES, LL.D., President of the University of Toronto. Canada.
1883. *LOUIS, D. A., F.C.S. 77 Shirland-gardens, W.
1896. §Louis, Henry, M.A., Professor of Mining, Durham College of Science, Newcastle-on-Tyne.
1887. *LOVE, Professor A. E. H., M.A., F.R.S. 34 St. Margaret's-road, Oxford.
1886. *Love, E. F. J., M.A. The University, Melbourne, Australia.
1876. *Love, James, F.R.A.S., F.G.S., F.Z.S. 33 Clanricarde-gardens, W.
1883. ‡Love, James Allen. 8 Eastbourne-road West, Southport.
1875. *Lovett, W. Jesse. 25 Bewlay-street, York.
1892. §Lovibond, J. W. Salisbury, Wiltshire.
1889. ‡*Low, Charles W. 84 Westbourne-terrace, W.*
1885. §Lowdell, Sydney Poole. Baldwin's Hill, East Grinstead, Sussex.
1891. ‡Lowdon, John. St. Hilda's, Barry, Glamorgan.
1885. *Lowe, Arthur C. W. Gosfield Hall, Halstead, Essex.
1892. ‡Lowe, D. T. Heriot's Hospital, Edinburgh.
1886. *Lowe, John Landor, B.Sc., M.Inst.C.E. Strathavon, Kedleston-road, Derby.
1894. ‡Lowenthal, Miss Nellie. 60 New North-road, Huddersfield.
1881. ‡Lubbock, Arthur Rolfe. High Elms, Farnborough, R.S.O., Kent.
1881. ‡Lubbock, John B. 14 Berkeley-street, W.

Year of
Election.
1870. ‡Lubbock, Montague, M.D. 19 Grosvenor-street, W.
1889. ‡Lucas, John. 1 Carlton-terrace, Low Fell, Gateshead.
1901. *Lucas, Keith. Greenhall, Forest Row, Sussex.
1878. ‡Lucas, Joseph. Tooting Graveney, S.W.
1889. ‡Luckley, George. The Grove, Jesmond, Newcastle-upon-Tyne.
1891. *Lucovich, Count A. The Rise, Llandaff.
1881. ‡Luden, C. M. 4 Bootham-terrace, York.
1897. ‡Lumsden, George E., F.R.A.S. 57 Elm-avenue, Toronto, Canada.
1866. *Lund, Charles. Ilkley, Yorkshire.
1873. ‡Lund, Joseph. Ilkley, Yorkshire.
1850. *Lundie, Cornelius. 32 Newport-road, Cardiff.
1892. ‡Lunn, Robert. Geological Survey Office, Sheriff Court House, Edinburgh.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1883. *Lupton, Arnold, M.Inst.C.E., F.G.S. 6 De Grey-road, Leeds.
1874. *LUPTON, SYDNEY, M.A. (Local Sec. 1890). 102 Park-street, Grosvenor-square, W.
1900. ‡LUPTON, WILLIAM C. Bradford.
1864. *Lutley, John. Brockhampton Park, Worcester.
1898. §Luxmoore, Dr. C. M. Reading College, Reading.
1871. ‡Lyell, Sir Leonard, Bart., F.G.S. 48 Eaton-place, S.W.
1899. ‡Lyle, Professor Thomas R. The University, Melbourne.
1884. ‡Lyman, A. Clarence. 84 Victoria-street, Montreal, Canada.
1884. ‡Lyman, H. H. 74 McTavish-street, Montreal, Canada.
1874. ‡Lynam, James. Ballinasloe, Ireland.
1885. ‡Lyon, Alexander, jun. 52 Carden-place, Aberdeen.
1896. ‡Lyster, A. G. Dockyard, Coburg Dock, Liverpool.
1862. *LYTE, F. MAXWELL, M.A., F.C.S. 60 Finborough-road, S.W.

1868. ‡MACALISTER, ALEXANDER, M.A., M.D., F.R.S. (Pres. H, 1892; Council, 1901–), Professor of Anatomy in the University of Cambridge. Torrisdale, Cambridge.
1878. ‡MACALISTER, DONALD, M.A., M.D., B.Sc. St. John's College, Cambridge.
1896. ‡*Macalister, R. A. S. 2 Gordon-street, W.C.*
1897. ‡McAllister, Samuel. 99 Wilcox-street, Toronto, Canada.
1896. §MACALLUM, Professor A. B., Ph.D. (Local Sec. 1897). 59 St. George-street, Toronto, Canada.
1879. §MacAndrew, James J., F.L.S. Lukesland, Ivybridge, South Devon.
1883. ‡MacAndrew, Mrs. J. J. Lukesland, Ivybridge, South Devon.
1883. §MacAndrew, William. Westwood House, near Colchester.
1866. *M'Arthur, Alexander. 79 Holland-park, W.
1896. ‡McArthur, Charles. Villa Marina, New Brighton, Cheshire.
1884. ‡Macarthur, D. Winnipeg, Canada.
1896. *Macaulay, F. S., M.A. 19 Dewhurst-road, W.
1896. ‡MACBRIDE, Professor E. W., M.A. McGill University, Montreal, Canada.
1884. ‡McCabe, T., Chief Examiner of Patents. Patent Office, Ottawa, Canada.
1902. *Maccall, W. T., M.Sc. Dalton Hall, Victoria Park, Manchester.
1886. ‡MacCarthy, Rev. E. F. M., M.A. 93 Hagley-road, Birmingham.
1887. *McCarthy, James. Care of Sir Sherston Baker, Bart., 18 Cavendish-road, Regent's Park, N.W.
1884. *McCarthy, J. J., M.D. 83 Wellington-road, Dublin.
1884. ‡McCausland, Orr. Belfast.
1891. *McCLEAN, FRANK, M.A., LL.D., F.R.S., M.Inst.C.E. Rusthall House, Tunbridge Wells.

Year of Election.
1876. *M‘CLELLAND, A. S. 4 Crown-gardens, Dowanhill, Glasgow.
1902. §McClelland, J. A., M.A., Professor of Physics in University College, Dublin.
1868. ‡M‘CLINTOCK, Admiral Sir FRANCIS L., R.N., K.C.B., F.R.S., F.R.G.S. United Service Club, Pall Mall, S.W.
1878. *M‘Comas, Henry. Pembroke House, Pembroke-road, Dublin.
1901. *MacConkey, Alfred. Jenner Institute of Preventive Medicine, Chelsea-gardens, S.W.
1901. §MacCormac, J.M., M.D. 31 Victoria-place, Belfast.
1892. *McCowan, John, M.A., D.Sc. Henderson-street, Bridge of Allan, N.B.
1892. ‡McCrae, George. 3 Dick-place, Edinburgh.
1901. ‡McCrae, John, Ph.D. 7 Kirklee-gardens, Glasgow.
1899. ‡McDiarmid, Jabez. The Elms, Stanmore, Middlesex.
1900. ‡MacDonald, J. R. 3 Lincoln's Inn-fields, W.C.
1890. *MacDonald, Mrs. J. R. 3 Lincoln's Inn-fields, W.C.
1886. ‡McDonald, John Allen. Hillsboro' House, Derby.
1884. ‡MacDonald, Kenneth. Town Hall, Inverness.
1884. *McDonald, Sir W. C. 891 Sherbrooke-street, Montreal, Canada.
1884. ‡MacDonnell, Mrs. F. H. 1433 St. Catherine-street, Montreal, Canada.
MacDonnell, Hercules H. G. 2 Kildare-place, Dublin.
1884. ‡McDougall, John. 35 St. François Xavier-street, Montreal, Canada.
1897. ‡McEwen, William C 9 South Charlotte-street, Edinburgh.
1902. §Macfadyen, Allan, M.D., B.Sc. Jenner Institute of Preventive Medicine, Chelsea-gardens, S.W.
1881. ‡Macfarlane, Alexander, D.Sc., F.R.S.E., Professor of Physics in the University of Texas. Austin, Texas, U.S.A.
1885. ‡Macfarlane, J. M., D.Sc., F.R.S.E., Professor of Biology in the University of Pennsylvania, Lansdowne, Delaware Co., Pennsylvania, U.S.A.
1897. ‡McFarlane, Murray, M D. 32 Carlton-street, Toronto, Canada.
1879. ‡Macfarlane, Walter, jun. 12 Lynedoch-crescent, Glasgow.
1901. ‡Macfee, John. Marguerite, Blackhall, Paisley.
1867. *M‘Gavin, Robert. Ballumbie, Dundee.
1897. ‡McGaw, Thomas. Queen's Hotel, Toronto, Canada.
1888 ‡MacGeorge, James. 7 Stonor-road, Kensington, W.
1884. ‡MacGillivray, James. 42 Cathcart-street, Montreal, Canada.
1884. ‡MacGoun, Archibald, jun., B.A., B.C.L. Dunavon, Westmount, Montreal, Canada.
1884. *MACGREGOR, JAMES GORDON, M.A., D.Sc., F.R.S., F.R.S.E., Professor of Natural Philosophy, The University, Edinburgh.
1885. ‡M‘Gregor-Robertson, J., M.A., M.B. 26 Buchanan-street, Hillhead, Glasgow.
1902. §McIlroy, Archibald. Drumcairn, Deramore Park, Belfast.
1867. *MCINTOSH W. C., M.D., LL.D., F.R.S., F.R.S.E., F.L.S. (Pres. D, 1885), Professor of Natural History in the University of St. Andrews. 2 Abbotsford-crescent, St. Andrews, N.B.
1884. ‡McIntyre, John, M.D. Odiham, Hants.
1883. ‡Mack, Isaac A. Trinity-road, Bootle.
1884. §MacKay, A. H., B.Sc., LL.D., Superintendent of Education. Education Office, Halifax, Nova Scotia, Canada.
1885. §MACKAY, JOHN YULE, M.D., Professor of Anatomy in University College, Dundee.
1897. ‡McKay, T. W. G., M.D. Oshawa, Ontario, Canada.
1896. *McKechnie, Duncan. Eccleston Grange, Preston.
1873. ‡MCKENDRICK, JOHN G., M.D., LL.D., F.R.S., F.R.S.E. (Pres. I, 1901), Professor of Physiology in the University of Glasgow. 2 Buckingham-terrace, Glasgow.

Year of Election.

1897. ‡McKenzie, John J. 61 Madison-avenue, Toronto, Canada.
1884. ‡MacKenzie, Stephen, M.D. 18 Cavendish-square, W.
1884. ‡McKenzie, Thomas, B.A. School of Science, Toronto, Canada.
1901. *Mackenzie, Thomas Brown. Elenslee, Wilson-street, Motherwell.
1883. ‡Mackeson, Henry. Hythe, Kent.
1872. *Mackey, J. A. 175 Grange-road, S.E.
1867. ‡MACKIE, SAMUEL JOSEPH. 17 Howley-place, W.
1901. §Mackie, William, M.D. 13 North-street, Elgin.
1884. ‡McKilligan, John B. 387 Main-street, Winnipeg, Canada.
1887. ‡MACKINDER, H. J., M.A., F.R.G.S. (Pres. E, 1895). Christ Church, Oxford.
1891. ‡Mackintosh, A. C. 88 Plymouth-road, Penarth.
1850. ‡Macknight, Alexander. 20 Albany-street, Edinburgh.
1872. *McLACHLAN, ROBERT, F.R.S., F.L.S. West View, Clarendon-road, Lewisham, S.E.
1896. ‡Maclagan, Miss Christian. Ravenscroft, Stirling.
1892. ‡Maclagan, Philip R. D. St. Catherine's, Liberton, Midlothian.
1892. ‡Maclagan, R. Craig, M.D., F.R.S.E. 5 Coates-crescent, Edinburgh.
1885. *M'LAREN, The Hon. Lord, F.R.S.E., F.R.A.S. 46 Moray-place, Edinburgh.
1897. ‡MacLaren, J. F. 380 Victoria-street, Toronto, Canada.
1901. ‡Maclaren, J. Malcolm. 62 Sydney-street, South Kensington, S.W.
1873. ‡MacLaren, Walter S. B. Newington House, Edinburgh.
1897. ‡MacLaren, Rev. Wm., D.D. 57 St. George-street, Toronto, Canada.
1901. ‡Maclay, James. 3 Woodlands-terrace, Glasgow.
1901. §Maclay, William. Thornwood, Langside, Glasgow.
1901. §McLean, Angus, B.Sc. Ascog, Meikleriggs, Paisley.
1892. *MACLEAN, MAGNUS, M.A., D.Sc., F.R.S.E. (Local Sec. 1901). Professor of Electrical Engineering, Technical College, Glasgow.
1884. ‡McLennan, Frank. 317 Drummond-street, Montreal, Canada.
1884. ‡McLennan, Hugh. 317 Drummond-street, Montreal, Canada.
1884. ‡McLennan, John. Lancaster, Ontario, Canada.
1868. §McLEOD, HERBERT, F.R.S. (Pres. B, 1892; Council, 1885-90). 9 Coverdale-road, Richmond, Surrey.
1892. ‡Macleod, W. Bowman. 16 George-square, Edinburgh.
1883. *McMAHON, Lieut.-General C. A., F.R.S., F.G.S. (Pres. C, 1902). 20 Nevern-square, South Kensington, S.W.
1883. ‡MACMAHON, Major PERCY A., R.A., D.Sc., F.R.S. (GENERAL SECRETARY, 1902- ; Pres. A, 1901; Council, 1898-1902). Queen Anne's-mansions, Westminster, S.W.
1878. *M'Master, George, M.A., J.P. Rathmines, Ireland.
1902. §McMordie, Robert J. Cabin Hill, Knock, Co. Down.
1884. ‡McMurrick, J. Playfair. University of Michigan, Ann Arbor, Michigan, U.S.A.
1867. ‡M'Neill, John. Balhousie House, Perth.
1878. ‡Macnie, George. 59 Bolton-street, Dublin.
1887. ‡Maconochie, A. W. Care of Messrs. Maconochie Bros., Lowestoft.
1883. ‡Macpherson, J. 44 Frederick-street, Edinburgh.
1901. §MacRitchie, David. 4 Archibald-place, Edinburgh.
*MACRORY, EDMUND, M.A., K.C. 19 Pembridge-square, W.
1902. §McWeeney, E. J., M.D. 84 Stephen's-green, Dublin.
1902. §McWhirter, William. 9 Walworth-terrace, Glasgow.
1887. ‡Macy, Jesse. Grinnell, Iowa, U.S.A.
1883. ‡Madden, W. H. Marlborough College, Wilts.
1883. ‡Maggs, Thomas Charles, F.G.S. 56 Clarendon-villas, West Brighton.
1902. §Magill, R., M.A., Ph.D. The Manse, Maghera, Co. Derry.

Year of Election.

1868. ‡Magnay, F. A. Drayton, near Norwich.
1875. *MAGNUS, Sir PHILIP, B.Sc. 16 Gloucester-terrace, Hyde Park, W.
1896. ‡Maguire, Thomas Philip. Eastfield, Lodge-lane, Liverpool.
1902. §Mahon, J. L. 29 Lower Sackville-street, Dublin.
1878. ‡Mahony, W. A. 34 College-green, Dublin.
1887. ‡*Mainprice, W. S. Longcroft, Altrincham, Cheshire.*
1883. ‡Maitland, P. C. 136 Great Portland-street, W.
1899. ‡Makarius, Saleem. 'Al Mokattam,' Cairo.
1881. ‡*Malcolm, Lieut.-Colonel, R.E. 72 Nunthorpe-road, York.*
1874. ‡Malcolmson, A. B. Friends' Institute, Belfast.
1857. ‡MALLET, JOHN WILLIAM, Ph.D., M.D., F.R.S., F.C.S., Professor of Chemistry in the University of Virginia, Albemarle Co., U.S.A.
1896. *Manbré, Alexandre. 15 Alexandra-drive, Liverpool.
1897. ‡MANCE, Sir H. C. 32 Earl's Court-square, S.W.
1887. ‡MANCHESTER, The Right Rev. the Lord Bishop of, D.D. Bishop's Court, Manchester.
1870. ‡*Manifold, W. H., M.D. 45 Rodney-street, Liverpool.*
1901. §Mann, John, jun., M.A. 137 West George-street, Glasgow.
1888. ‡Mann, W. J. Rodney House, Trowbridge.
1894. ‡Manning, Percy, M.A., F.S.A. Watford, Herts.
1864. ‡Mansel-Pleydell, J. C., F.G.S. Whatcombe, Blandford, Dorset.
1888. ‡MANSERGH, JAMES, M.Inst.C.E., F.R.S., F.G.S. 5 Victoria-street, Westminster, S.W.
1891. ‡Manuel, James. 175 Newport-road, Cardiff.
1887. *March, Henry Colley, M.D., F.S.A. Portesham, Dorchester, Dorsetshire.
1902. *Marchant, Dr. E. W. University College, Liverpool.
1870. ‡Marcoartu, His Excellency Don Arturo de. Madrid.
1898. *Mardon, Heber. 2 Litfield-place, Clifton, Bristol.
1900. ‡Margerison, Samuel. Calverley Lodge, near Leeds.
1887. ‡*Margetson, J. Charles. The Rocks, Limpley, Stoke.*
1883. ‡Marginson, James Fleetwood. The Mount, Fleetwood, Lancashire.
1887. ‡Markham, Christopher A., F.R.Met.Soc. Spratton, Northampton.
1864. ‡MARKHAM, Sir CLEMENTS R., K.C.B., F.R.S., Pres.R.G.S., F.S.A. (Pres. E, 1879; Council 1893–96). 21 Eccleston-square, S.W.
1863. ‡Marley, John. Mining Office, Darlington.
1888. ‡Marling, W. J. Stanley Park, Stroud, Gloucestershire.
1888. ‡Marling, Lady. Stanley Park, Stroud, Gloucestershire.
1881. *MARR, J. E., M.A., F.R.S., F.G.S. (Pres. C, 1896; Council 1896–1902). St. John's College, Cambridge.
1887. ‡Marsden, Benjamin. Westleigh, Heaton Mersey, Manchester.
1884. *Marsden, Samuel. 1015 North Leffingwell-avenue, St. Louis, Missouri, U.S.A.
1892. *Marsden-Smedley, J. B. Lea Green, Cromford, Derbyshire.
1883. *Marsh, Henry. 72 Wellington Street, Leeds.
1887. ‡Marsh, J. E., M.A. The Museum, Oxford.
1864. ‡Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
1889. *MARSHALL, ALFRED, M.A., LL.D. (Pres. F, 1890), Professor of Political Economy in the University of Cambridge. Balliol Croft, Madingley-road, Cambridge.
1892. §Marshall, Hugh, D.Sc., F.R.S.E. 12 Lonsdale-terrace, Edinburgh.
1890. ‡Marshall, John. Derwent Island, Keswick.
1901. §Marshall, Robert. 97 Wellington-street, Glasgow.
1886. *MARSHALL, WILLIAM BAYLEY, M.Inst.C.E. Richmond Hill, Edgbaston, Birmingham.

Year of
Election.

1849. *MARSHALL, WILLIAM P., M.Inst.C.E. Richmond Hill, Edgbaston, Birmingham.
1865. ‡MARTEN, EDWARD BINDON. Pedmore, near Stourbridge.
1899. §Martin, Miss A. M. Park View, 32 Bayham-road, Sevenoaks.
1891. *Martin, Edward P., J.P. Dowlais, Glamorgan.
1887. *Martin, Rev. H. A. Grosvenor Club, Grosvenor-crescent, S.W.
1884. §Martin, N. H., J.P., F.L.S. Ravenswood, Low Fell, Gateshead-on-Tyne.
1889. *Martin, Thomas Henry, Assoc.M.Inst.C.E. Northdene, New Barnet, Herts.
1865. ‡Martineau, R. F. 18 Highfield-road, Edgbaston, Birmingham.
1883. ‡MARWICK, Sir J. D., LL.D., F.R.S.E. (Local Sec. 1871, 1876, 1901). Glasgow.
1891. ‡Marychurch, J. G. 46 Park-street, Cardiff.
1873. *MASHAM, Lord. Swinton Park, Swinton.
1847. ‡MASKELYNE, NEVIL STORY, M.A., F.R.S., F.G.S. (Council 1874–80). Basset Down House, Swindon.
1886. ‡Mason, Hon. J. E. Fiji.
1896. ‡Mason, Philip B., F.L.S., F.Z.S. Burton-on-Trent.
1893. *Mason, Thomas. Endersleigh, Alexandra Park, Nottingham.
1891. *Massey, William H., M.Inst.C.E. Twyford, R.S.O., Berkshire.
1885. ‡Masson, Orme, D.Sc. University of Melbourne, Victoria, Australia.
1898. ‡Masterman, A. T. University of St. Andrews, N.B.
1901. *Mather, G. R. Boxlea, Wellingborough.
1883. ‡Mather, Robert V. Birkdale Lodge, Birkdale, Southport.
1887. *Mather, Sir William, M.P., M.Inst.C.E. Salford Iron Works, Manchester.
1890. ‡*Mathers, J. S. 1 Hanover-square, Leeds.*
1865. ‡Mathews, C. E. Waterloo-street, Birmingham.
1898. ‡Mathews, E. R. Norris. Cotham-road, Cotham, Bristol.
1894. ‡MATHEWS, G. B., M.A., F.R.S. St. John's College, Cambridge.
1865. *Mathews, G. S. 32 Augustus-road, Edgbaston, Birmingham.
1889. ‡Mathews, John Hitchcock. 1 Queen's-gardens, Hyde Park, W.
1881. ‡Mathwin, Henry, B.A. 26 Oxford-road, Birkdale, Southport.
1883. ‡Mathwin, Mrs. H. 26 Oxford-road, Birkdale, Southport.
1902. §Matley, C. A. 90 St. Lawrence-road, Clontarf, Dublin.
1858. ‡Matthews, F. C. Mandre Works, Driffield, Yorkshire.
1885. ‡MATTHEWS, JAMES. Springhill, Aberdeen.
1885. ‡Matthews, J. Duncan. Springhill, Aberdeen.
1899. ‡MATTHEWS, WILLIAM, C.M.G., M.Inst.C.E. 9 Victoria-street, S.W.
1893. ‡Mavor, Professor James, M.A., LL.D. University of Toronto, Canada.
1865. *MAW, GEORGE, F.L.S., F.G.S., F.S.A. Benthall, Kenley, Surrey.
1894. §Maxim, Sir Hiram S. 18 Queen's Gate-place, Kensington, S.W.
*Maxwell, Robert Perceval. Finnebrogue, Downpatrick.
1883. §May, William, F.G.S. Northfield, St. Mary Cray, Kent.
1901. *May, W. Page, M.D., B.Sc. 9 Manchester-square, W.
1884. *Maybury, A. C., D.Sc. 8 Heathcote-street, W.C.
1878. *Mayne, Thomas. 33 Castle-street, Dublin.
1871. ‡Meikle, James, F.S.S. 6 St. Andrew's-square, Edinburgh.
1879. §Meiklejohn, John W. S., M.D. 105 Holland-road, W.
1887. ‡Meischke-Smith, W. Rivala Lumpore, Salengore, Straits Settlements.
1881. *MELDOLA, RAPHAEL, F.R.S., F.R.A.S., F.C.S., F.I.C. (Pres. B, 1895; Council 1892–99), Professor of Chemistry in the Finsbury Technical College, City and Guilds of London Institute. 6 Brunswick-square, W.C.
1883. ‡Mellis, Rev. James. 23 Part-street, Southport.

Year of Election.
1879. *Mellish, Henry. Hodsock Priory, Worksop.
1866. ‡MELLO, Rev. J. M., M.A., F.G.S. Cliff Hill, Warwick.
1883. ‡Mello, Mrs. J. M. Cliff Hill, Warwick.
1896. §Mellor, G. H. Weston, Blundellsands, Liverpool.
1881. §Melrose, James. Clifton Croft, York.
1887. ‡Melvill, J. Cosmo, M.A. Kersal Cottage, Prestwich, Manchester.
1863. ‡Melvin, Alexander. 42 Buccleuch-place, Edinburgh.
1896. ‡Menneer, R. R. Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1901. ‡Mennell, F. P. 8 Addison-road, W.
1862. ‡MENNELL, HENRY T. St. Dunstan's-buildings, Great Tower-street, E.C.
1879. ‡MERIVALE, JOHN HERMAN, M.A. (Local Sec. 1889). Togston Hall, Acklington.
1899. *Merrett, William H. Hatherley, Grosvenor-road, Wallington, Surrey.
1880. ‡*Merry, Alfred S. Bryn Heulog, Sketty, near Swansea.*
1899. §Merryweather, J. C. 4 Whitehall-court, S.W.
1889. *Merz, John Theodore. The Quarries, Newcastle-upon-Tyne.
1863. ‡Messent, P. T. 4 Northumberland-terrace, Tynemouth.
1896. §Metzler, W. H., Professor of Mathematics in Syracuse University, Syracuse, New York, U.S.A.
1869. ‡MIALL, LOUIS C., F.R.S., F.L.S., F.G.S. (Pres. D, 1897; Local Sec. 1890), Professor of Biology in the Yorkshire College, Leeds.
1886. ‡Middlemore, Thomas. Holloway Head, Birmingham.
1865. ‡Middlemore, William. Edgbaston, Birmingham.
1881. *Middlesbrough, The Right Rev. Richard Lacy, D.D., Bishop of. Middlesbrough.
1893. ‡Middleton, A. 25 Lister-gate, Nottingham.
1881. ‡Middleton, R. Morton, F.L.S., F.Z.S. 46 Windsor-road, Ealing, W.
1894. *MIERS, H. A., M.A., F.R.S., F.G.S., Professor of Mineralogy in the University of Oxford. Magdalen College, Oxford.
1889. ‡Milburn, John D. Queen-street, Newcastle-upon-Tyne.
1886. ‡Miles, Charles Albert. Buenos Ayres.
1881. ‡MILES, MORRIS (Local Sec. 1882). Warbourne, Hill-lane, Southampton.
1885. §MILL, HUGH ROBERT, D.Sc., LL.D., F.R.S.E., F.R.G.S. (Pres. E, 1901). 22 Gloucester-place, Portman-square, W.
1889. *Millar, Robert Cockburn. 30 York-place, Edinburgh.
Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.
1875. ‡*Miller, George. Brentry, near Bristol.*
1895. ‡Miller, Henry, M.Inst.C.E. Bosmere House, Norwich-road, Ipswich.
1888. ‡Miller, J. Bruce. Rubislaw Den North, Aberdeen.
1885. ‡Miller, John. 9 Rubislaw-terrace, Aberdeen.
1886. ‡Miller, Rev. John, B.D. The College, Weymouth.
1861. *Miller, Robert. Totteridge House, Hertfordshire, N.
1895. §Miller, Thomas, M.Inst.C.E. 9 Thoroughfare, Ipswich.
1884. ‡Miller, T. F., B.Ap.Sc. Napanee, Ontario, Canada.
1876. ‡Miller, Thomas Paterson. Cairns, Cambuslang, N.B.
1897. ‡Miller, Willet G., Professor of Geology in Queen's University, Kingston, Ontario, Canada.
1902. §Millin, S. T. Sheridan Lodge, Helen's Bay, Co. Down.
1868. *MILLS EDMUND J., D.Sc., F.R.S., F.C.S. 11 Greenhill-road, Harrow.
1880. ‡Mills, Mansfeldt H., M.Inst.C.E., F.G.S. Sherwood Hall, Mansfield.

Year of Election.

1902. §Mills, W. Sloan, M.A. Vine Cottage, Donaghmore, Newry.
1885. ‡Milne, Alexander D. 40 Albyn-place, Aberdeen.
1882. *MILNE, JOHN, F.R.S., F.G.S. Shide Hill House, Shide, Isle of Wight.
1885. ‡Milne, William. 40 Albyn-place, Aberdeen.
1898. *Milner, S. Roslington, B.Sc. University College, Sheffield.
1882. ‡Milnes, Alfred, M.A., F.S.S. 22A Goldhurst-terrace, South Hampstead, N.W.
1880. ‡MINCHIN, G. M., M.A., F.R.S., Professor of Mathematics in the Royal Indian Engineering College, Cooper's Hill, Surrey.
1855. ‡Mirrlees, James Buchanan. 45 Scotland-street, Glasgow.
1859. ‡Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1901. *Mitchell, Andrew Acworth. 7 Huntly-gardens, Glasgow.
1883. ‡Mitchell, Charles T., M.A. 41 Addison-gardens North, Kensington, W.
1883. ‡Mitchell, Mrs. Charles T. 41 Addison-gardens North, Kensington, W.
1901. *Mitchell, G. A. 5 West Regent-street, Glasgow.
1885. ‡Mitchell, P. Chalmers. Christ Church, Oxford.
1895. *Moat, William, M.A. Johnson, Eccleshall, Staffordshire.
1885. ‡Moffat, William. 7 Queen's-gardens, Aberdeen.
1885. ‡Moir, James. 25 Carden-place, Aberdeen.
1883. ‡Mollison, W. L., M.A. Clare College, Cambridge.
1877. *Molloy, Right Rev. Gerald, D.D. 86 Stephen's-green, Dublin.
1884. ‡Monaghan, Patrick. Halifax (Box 317), Nova Scotia, Canada.
1900. §MONCKTON, H. W., F.G.S. 3 Harcourt-buildings, Temple, E.C.
1887. *MOND, LUDWIG, Ph.D., F.R.S., F.C.S. (Pres. B, 1896). 20 Avenue-road, Regent's Park, N.W.
1891. *Mond, Robert Ludwig, M.A., F.R.S.E., F.G.S. 20 Avenue-road, Regent's Park, N.W.
1882. *Montagu, Sir Samuel, Bart., M.P. 12 Kensington Palace-gardens, W.
1892. ‡Montgomery, Very Rev. J. F. 17 Athole-crescent, Edinburgh.
1872. ‡Montgomery, R. Mortimer. 3 Porchester-place, Edgware-road, W.
1872. ‡Moon, W., LL.D. 104 Queen's-road, Brighton.
1896. ‡Moore, A. W., M.A. Woodbourne House, Douglas, Isle of Man.
1894. §Moore, Harold E. Oaklands, The Avenue, Beckenham, Kent.
1890. ‡Moore, Major, R.E. School of Military Engineering, Chatham.
1901. *Moore, Robert T. 156 St. Vincent-street, Glasgow.
1896. *Mordey, W. M. Prince's-mansions, Victoria-street, S.W.
1891. ‡Morel, P. Lavernock House, near Cardiff.
1901. *Moreno, Francisco P. Argentine Legation, 16 Kensington Palace-gardens, W.
1881. ‡MORGAN, ALFRED. 50 West Bay-street, Jacksonville, Florida, U.S.A.
1895. ‡MORGAN, C. LLOYD, F.R.S., F.G.S., Principal of University College, Bristol. 16 Canynge-road, Clifton, Bristol.
1873. ‡Morgan, Edward Delmar, F.R.G.S. 15 Roland-gardens, South Kensington, S.W.
1891. ‡Morgan, F. Forest Lodge, Ruspidge, Gloucestershire.
1896. §Morgan, George. 21 Upper Parliament-street, Liverpool.
1902. §MORGAN, GILBERT T., D.Sc., F.I.C. Royal College of Science, S.W.
1887. ‡Morgan, John Gray. 38 Lloyd-street, Manchester.
1902. *Morgan, Septimus Vaughan. 37 Harrington-gardens, S.W.
1882. ‡Morgan, Thomas, J.P. Cross House, Southampton.
1901. *Morison, James. Perth.
1892. ‡Morison, John, M.D., F.G.S. Victoria-street, St. Albans.
1889. §Morison, J. Rutherford, M.D. 14 Saville-row Newcastle-upon-Tyne.

Year of Election.

1893. ‡Morland, John, J.P. Glastonbury.

1891. ‡Morley, H. The Gas Works, Cardiff.

1883. *MORLEY, HENRY FORSTER, M.A., D.Sc., F.C.S. 5 Lyndhurst-road, Hampstead, N.W.

1889. ‡MORLEY, The Right Hon. JOHN, M.A., LL.D., M.P., F.R.S. 95 Elm Park-gardens, S.W.

1896. ‡Morrell, R. S. Caius College, Cambridge.

1881. ‡Morrell, W. W. York City and County Bank, York.

1883. ‡Morris, C. S. Millbrook Iron Works, Landore, South Wales.

1892. †MORRIS, DANIEL, C.M.G., M.A., D.Sc., F.L.S. Barbados, West Indies.

1890. ‡Morris, G. Harris, B.Sc., Ph.D., F.I.C. Helenslea, South Hill Park, Bromley, Kent.

1883. †Morris, George Lockwood. Millbrook Iron Works, Swansea.

1880. §Morris, James. 6 Windsor-street, Uplands, Swansea.

1896. *Morris, J. T. 13 Somers-place, W.

1888. ‡Morris, J. W. 27 Green Park, Bath.

Morris, Samuel, M.R.D.S. Fortview, Clontarf, near Dublin.

1874. ‡Morrison, G. J., M.Inst.C.E. Shanghai, China.

1871. *Morrison, J. D. Fordel Castle, Glenfarg, Perthshire.

1899. §Morrow, Captain John, M.Sc. 7 Rockleaze-avenue, Sneyd Park, Bristol.

1865. ‡Mortimer, J. R. St. John's-villas, Driffield.

1869. ‡Mortimer, William. Bedford-circus, Exeter.

1858. *MORTON, HENRY JOSEPH. 2 Westbourne-villas, Scarborough.

1887. ‡Morton, Percy, M.A. Illtyd House, Brecon, South Wales.

1886. *Morton, P. F. 15 Ashley-place, Westminster, S.W.

1896. *MORTON, WILLIAM B., M.A., Professor of Natural Philosophy in Queen's College, Belfast.

1878. *MOSS, JOHN FRANCIS, F.R.G.S. (Local Sec. 1879). Beechwood, Brincliffe, Sheffield.

1876. §MOSS, RICHARD JACKSON, F.I.C., M.R.I.A. Royal Dublin Society, and St. Aubyn's, Ballybrack, Co. Dublin.

1864. *Mosse, J. R. 5 Chiswick-place, Eastbourne.

1892. ‡Mossman, R. C., F.R.S.E. 10 Blacket-place, Edinburgh.

1873. ‡Mossman, William. St. Hilda's, Frizinghall, Bradford.

1892. *Mostyn, S. G., M.A., M.B. City Hospital for Infectious Diseases, Walker Gate, Newcastle-upon-Tyne.

1866. ‡MOTT, FREDERICK T., F.R.G.S. Crescent House, Leicester.

1856. ‡Mould, Rev. J. G., B.D. Roseland, Meadfoot, Torquay.

1878. *MOULTON, J. FLETCHER, M.A., K.C., M.P., F.R.S. 57 Onslow-square, S.W.

1863. ‡Mounsey, Edward. Sunderland.

1877. ‡MOUNT-EDGCUMBE, The Right Hon. the Earl of, D.C.L. Mount-Edgcumbe, Devonport.

1899. §Mowll, Martyn. Chaldercot, Leyburne-road, Dover.

1887. ‡Moxon, Thomas B. County Bank, Manchester.

1888. ‡Moyle, R. E., M.A., F.C.S. Heightley, Chudleigh, Devon.

1884. ‡Moyse, C. E., B.A., Professor of English Language and Literature in McGill College, Montreal. 802 Sherbrooke-street, Montreal, Canada.

1884. ‡Moyse, Charles E. 802 Sherbrooke-street, Montreal, Canada.

1899. *Muff, Herbert B. Geological Survey Office, Edinburgh.

1894. ‡Mugliston, Rev. J., M.A. Newick House, Cheltenham.

1902. §Muir, Arthur H., C.A. 2 Wellington-place, Belfast.

1876. *Muir, Sir John, Bart. Demster House, Perthshire.

1874. ‡MUIR, M. M. PATTISON, M.A. Gonville and Caius College, Cambridge.

Year of Election.

1872. *MUIRHEAD, ALEXANDER, D.Sc., F.C.S. 2 Prince's-street, Storey's-gate, Westminster, S.W.
1876. *Muirhead, Robert Franklin, M.A., B.Sc. 24 Kersland-street, Hillhead, Glasgow.
1883. ‡Mulhall, Mrs. Marion. Fancourt, Balbriggan, Co. Dublin.
1902. §Mullan, James. Castlerock, Co. Derry.
1884. *MÜLLER, HUGO, Ph.D., F.R.S., F.C.S. 13 Park-square East, Regent's Park, N.W.
1880. ‡Muller, Hugo M. 1 Grünanger-gasse, Vienna.
1897. ‡Mullins, W. E. Preshute House, Marlborough, Wilts.
1898. ‡Mumford, C. E. Bury St. Edmunds.
1901. *Munby, Alan E. Felstead, Essex.
Munby, Arthur Joseph. 6 Fig Tree-court, Temple, E.C.
1876. ‡Munro, Donald, M.D., F.C.S. The University, Glasgow.
1901. ‡Munro, Donald, M.D., J.P. Wheatholm, Pollokshaws, Glasgow.
1898. ‡Munro, John, Professor of Mechanical Engineering in the Merchant Venturers' Technical College, Bristol.
1883. *MUNRO, ROBERT, M.A., M.D. (Pres. H, 1893). 48 Manor-place, Edinburgh.
1855. ‡Murdoch, James Barclay. Capelrig, Mearns, Renfrewshire.
1890. ‡Murphy, A. J. Preston House, Leeds.
1889. ‡Murphy, James, M.A., M.D. Holly House, Sunderland.
1884. §Murphy, Patrick. Marcus-square, Newry, Ireland.
1887. ‡Murray, A. Hazeldean, Kersal, Manchester.
1891. ‡MURRAY, G. R. M., F.R.S., F.R.S.E., F.L.S. British Museum (Natural History), South Kensington, S.W.
1859. ‡Murray, John, M.D. Forres, Scotland.
1884. ‡MURRAY, Sir JOHN, K.C.B., LL.D., Ph.D., F.R.S., F.R.S.E. (Pres. E, 1899). Challenger Lodge, Wardie, Edinburgh.
1884. ‡Murray, J. Clark, LL.D., Professor of Logic and Mental and Moral Philosophy in McGill University, Montreal. 111 McKay-street, Montreal, Canada.
1872. ‡Murray, J. Jardine, F.R.C.S.E. 99 Montpellier-road, Brighton.
1892. ‡Murray, T. S. 1 Nelson-street, Dundee.
1863. ‡Murray, William, M.D. 9 Ellison-place, Newcastle-on-Tyne.
1874. §Musgrave, Sir James, Bart., D.L. Drumglass House, Belfast.
1897. ‡Musgrave, James, M.D. 511 Bloor-street West, Toronto, Canada.
1870. *Muspratt, Edward Knowles. Seaforth Hall, near Liverpool.
1891. ‡Muybridge, Eadweard. University of Pennsylvania, Philadelphia, U.S.A.
1902. §Myddleton, Alfred. 62 Duncairn-street, Belfast.
1902. *Myers, Charles S., M.A., M.D. 62 Holland-park, W.
1890. *MYRES, JOHN L., M.A., F.S.A. Christ Church, Oxford.

1886. ‡NAGEL, D. H., M.A. (Local Sec. 1894). Trinity College, Oxford.
1892. *Nairn, Michael B. Kirkcaldy, N.B.
1890. §Nalder, Francis Henry. 34 Queen-street, E.C.
1876. ‡Napier, James S. 9 Woodside-place, Glasgow.
1872. ‡NARES, Admiral Sir G. S., K.C.B., R.N., F.R.S., F.R.G.S. 11 Claremont-road, Surbiton.
1887. ‡Nason, Professor Henry B., Ph.D. Troy, New York, U.S.A.
1896. ‡Neal, James E., U.S. Consul. 26 Chapel-street, Liverpool.
1887. §Neild, Charles. 19 Chapel-walks, Manchester.
1883. *Neild, Theodore, B.A. The Vista, Leominster.
1887. ‡Neill, Robert, jun. Beech Mount, Higher Broughton, Manchester.
1855. ‡Neilson, Walter. 172 West George-street, Glasgow.

Year of Election.

1897. ‡Nesbitt, Beattie S. A., M.D. 71 Grosvenor-street, Toronto, Canada.
1868. ‡Nevill, Rev. H. R. The Close, Norwich.
1898. §Nevill, Rev. J. H. N., M.A. The Vicarage, Stoke Gabriel, South Devon.
1866. *Nevill, The Right Rev. Samuel Tarratt, D.D., F.L.S., Bishop of Dunedin, New Zealand.
1889. ‡NEVILLE, F. H., M.A., F.R.S. Sidney College, Cambridge.
1869. ‡Nevins, John Birkbeck, M.D. 3 Abercromby-square, Liverpool.
1889. *Newall, H. Frank, M.A., F.R.S., F.R.A.S. Madingley Rise, Cambridge.
1901. §Newbigin, Miss Marion I. Greenhill House, Alnwick.
1886. ‡Newbolt, F. G. Oakley Lodge, Weybridge, Surrey.
1901. §Newman, F. H. Tullie House, Carlisle.
1889. §Newstead, A. H. L., B.A. 38 Green-street, Bethnal Green, N.E.
1860. *NEWTON, ALFRED, M.A., F.R.S., F.L.S. (Pres. D, 1887; Council 1875–82). Professor of Zoology and Comparative Anatomy in the University of Cambridge. Magdalene College, Cambridge.
1892. ‡NEWTON, E. T., F.R.S., F.G.S. Geological Museum, Jermyn-street, S.W.
1867. ‡Nicholl, Thomas. Dundee.
1866. ‡NICHOLSON, Sir CHARLES, Bart., M.D., D.C.L., LL.D., F.G.S., F.R.G.S. (Pres. E, 1866). The Grange, Totteridge, Herts.
1887. *Nicholson, John Carr. Moorfield House, Headingley, Leeds.
1884. ‡NICHOLSON, JOSEPH S., M.A., D.Sc. (Pres. F, 1893), Professor of Political Economy in the University of Edinburgh. Eden Lodge, Newbattle-terrace, Edinburgh.
1883. ‡Nicholson, Richard, J.P. Whinfield, Hesketh Park, Southport.
1887. ‡Nicholson, Robert H. Bourchier. 21 Albion-street, Hull.
1893. ‡Nickolls, John B., F.C.S. The Laboratory, Guernsey.
1887. ‡Nickson, William. Shelton, Sibson-road, Sale, Manchester.
1901. ‡NICOL, JAMES, City Chamberlain. Glasgow.
1885. ‡Nicol, W. W. J., D.Sc., F.R.S.E. 15 Blacket-place, Edinburgh.
1896. ‡Nisbet, J. Tawse. 175 Lodge-lane, Liverpool.
1878. ‡NIVEN, CHARLES, M.A., F.R.S., F.R.A.S., Professor of Natural Philosophy in the University of Aberdeen. 6 Chanonry, Old Aberdeen.
1877. ‡Niven, Professor James, M.A. King's College, Aberdeen.
1863. *NOBLE, Sir ANDREW, Bart., K.C.B., F.R.S., F.R.A.S., F.C.S. (Pres. G, 1890; Local Sec. 1863). Elswick Works, and Jesmond Dene House, Newcastle-upon-Tyne.
1879. ‡Noble, T. S. Lendal, York.
1887. ‡Nodal, John H. The Grange, Heaton Moor, near Stockport.
1863. §NORMAN, Rev. Canon ALFRED MERLE, M.A., D.C.L., LL.D., F.R.S., F.L.S. The Red House, Berkhamsted.
1888. ‡Norman, George. 12 Brock-street, Bath.
1865. ‡NORRIS, RICHARD, M.D. 2 Walsall-road, Birchfield, Birmingham.
1872. ‡Norris, Thomas George. Gorphwysfa, Llanrwst, North Wales
1883. *Norris, William G. Dale House, Coalbrookdale, R.S.O., Shropshire
NORTON, The Right Hon. Lord, K.C.M.G. 35 Eaton-place, S.W.; and Hamshall, Birmingham.
1886. ‡Norton, Lady. 35 Eaton-place, S.W.; and Hamshall, Birmingham.
1894. §NOTCUTT, S. A., LL.M., B.A., B.Sc. (Local Sec. 1895). 98 Anglesea-road, and Constitution Hill, Ipswich.
Nowell, John. Farnley Wood, near Huddersfield.
1896. ‡Nugent, the Right Rev. Monsignor. 18 Adelaide-terrace, Waterloo, Liverpool.

Year of Election.

1898. *O'Brien, Neville Forth. Queen Anne's-mansions, S.W.
1878. ‡O'Conor Don, The. Clonalis, Castlerea, Ireland.
1883. ‡Odgers, William Blake, M.A., LL.D. 4 Elm-court, Temple, E.C.
1858. ***ODLING, WILLIAM**, M.B., F.R.S., V.P.C.S. (Pres. B, 1864; Council 1865–70), Waynflete Professor of Chemistry in the University of Oxford. 15 Norham-gardens, Oxford.
1884. ‡Odlum, Edward, M.A. Pembroke, Ontario, Canada.
1857. ‡O'Donnavan, William John. 54 Kenilworth-square, Rathgar, Dublin.
1894. §Ogden, James. Kilner Deyne, Rochdale.
1902. §Ogden, James Neal. Claremont, Heaton Chapel, Stockport.
1896. ‡Ogden, Thomas. 4 Prince's-avenue, Liverpool.
1885. ‡Ogilvie, Alexander, LL.D. Gordon's College, Aberdeen.
1876. ‡Ogilvie, Campbell P. Sizewell House, Leiston, Suffolk.
1885. ‡**OGILVIE, F. GRANT**, M.A., B.Sc., F.R.S.E. (Local Sec. 1892). Heriot Watt College, Edinburgh.
1859. ‡Ogilvy, Rev. C. W. Norman. Baldan House, Dundee.
*Ogle, William, M.D., M.A. The Elms, Duffield-road, Derby.
1884. ‡O'Halloran, J. S., C.M.G. Royal Colonial Institute, Northumberland-avenue, W.C.
1881. ‡Oldfield, Joseph. Lendal, York.
1887. ‡*Oldham, Charles. Romiley, Cheshire.*
1896. ‡Oldham, G. S. Town Hall, Birkenhead.
1892. ‡**OLDHAM, H. YULE**, M.A., F.R.G.S., Lecturer in Geography in the University of Cambridge. King's College, Cambridge.
1853. ‡**OLDHAM, JAMES**, M.Inst.C.E. Cottingham, near Hull.
1885. ‡Oldham, John. River Plate Telegraph Company, Monte Video.
1893. ***OLDHAM, R. D.**, F.G.S., Geological Survey of India. Care of Messrs. H. S. King & Co., Cornhill, E.C.
1863. ‡**OLIVER, DANIEL**, LL.D., F.R.S., F.L.S., Emeritus Professor of Botany in University College, London. 10 Kew Gardens-road, Kew, Surrey.
1887. ‡**OLIVER, F. W.**, D.Sc., F.L.S., Professor of Botany in University College, London. 2 The Vale, Chelsea, S.W.
1883. §Oliver, Samuel A. Bellingham House, Wigan, Lancashire.
1889. §Oliver, Professor T., M.D. 7 Ellison-place, Newcastle-upon-Tyne.
1882. §Olsen, O. T., F.L.S., F.R.G.S. 116 St. Andrew's-terrace, Grimsby.
1860. ***OMMANNEY, Admiral Sir ERASMUS**, K.C.B., LL.D., F.R.S., F.R.A.S., F.R.G.S. (Pres. E, 1877; Council 1873–80, 1884–90). 29 Connaught-square, Hyde Park, W.
1880. *Ommanney, Rev. E. A. St. Michael's and All Angels, Portsea, Hants.
1902. §O'Neill, Henry, M.D. 6 College-square East, Belfast.
1902. §O'Neill, James, M.A. 5 College-square East, Belfast.
1872. ‡*Onslow, D. Robert. New University Club, St. James's, S.W.*
1883. ‡Oppert, Gustav, Professor of Sanskrit in the University of Berlin.
1902. §O'Reilly, Patrick Joseph. 7 North Earl-street, Dublin.
1899. ‡Orling, Axel. Moorgate Station-chambers, E.C.
1858. ‡Ormerod, T. T. Brighouse, near Halifax.
1883. ‡Orpen, Miss. St. Leonard's, Kilkenny, Co. Dublin.
1884. *Orpen, Lieut.-Colonel R. T., R.E. Monksgrange, Enniscorthy, Co. Wexford.
1884. *Orpen, Rev. T. H., M.A. Binnbrooke, Cambridge.
1901. §Orr, Alexander Stewart. Care of Messrs. Marsland, Price & Co., Mazagon, Bombay, India.
1899. ‡Osborn, Dr. F. A. The Châlet, Dover.
1897. ‡Osborne, James K. 40 St. Joseph-street, Toronto, Canada.

Year of Election.

1901. §Osborne, W. A., D.Sc. University College, W.C.

1887. §O'Shea, L. T., B.Sc. University College, Sheffield.

*OSLER, A. FOLLETT, F.R.S. South Bank, Edgbaston, Birmingham.

1897. ‡Osler, E. B., M.P. Rosedale, Toronto, Canada.

1865. *Osler, Henry F. Coppy Hill, Linthurst, near Bromsgrove, Birmingham.

1884. ‡OSLER, Professor WILLIAM, M.D., F.R.S. Johns Hopkins University, Baltimore, U.S.A.

1884. ‡_O'Sullivan, James, F.C.S._ 71 _Spring Terrace-road, Burton-on-Trent._

1882. *Oswald, T. R. Castle Hall, Milford Haven.

1881. *Ottewell, Alfred D. 14 Mill Hill-road, Derby.

1896. ‡Oulton, W. Hillside, Gateacre, Liverpool.

1882. ‡Owen, Rev. C. M., M.A. St. George's, Edgbaston, Birmingham.

1889. *Owen, Alderman H. C. Compton, Wolverhampton.

1896. §Owen, Peter. The Elms, Capenhurst, Chester.

1889. ‡Page, Dr. F. 1 Saville-place, Newcastle-upon-Tyne.

1883. ‡Page, George W. Fakenham, Norfolk.

1883. ‡Page, Joseph Edward. 12 Saunders-street, Southport.

1894. ‡Paget, Octavius. 158 Fenchurch-street, E.C.

1898. ‡Paget, The Right Hon. Sir R. H., Bart. Cranmore Hall, Shepton Mallet.

1884. ‡Paine, Cyrus F. Rochester, New York, U.S.A.

1875. ‡Paine, William Henry, M.D. Stroud, Gloucestershire.

1870. *PALGRAVE, ROBERT HARRY INGLIS, F.R.S., F.S.S. (Pres. F, 1883). Belton, Great Yarmouth.

1896. ‡Pallis, Alexander. Tatoi, Aigburth-drive, Liverpool.

1889. ‡PALMER, Sir CHARLES MARK, Bart., M.P. Grinkle Park, Yorkshire.

1878. *Palmer, Joseph Edward. Rose Lawn, Ballybrack, Co. Dublin.

1866. §Palmer, William. Waverley House, Waverley-street, Nottingham.

1872. *_Palmer, W. R._ 49 _Tierney-road, Streatham Hill, S.W._

1883. ‡_Pant, F. J. Van der._ _Clifton Lodge, Kingston-on-Thames._

1886. ‡Panton, George A., F.R.S.E. 73 Westfield-road, Edgbaston, Birmingham.

1883. ‡Park, Henry. Wigan.

1883. ‡Park, Mrs. Wigan.

1880. *Parke, George Henry, F.L.S., F.G.S. St. John's, Wakefield, Yorkshire.

1898. ‡Parker, G., M.D. 14 Pembroke-road, Clifton, Bristol.

1886. ‡Parker, Lawley. Chad Lodge, Edgbaston, Birmingham.

1899. ‡_Parker, Mark._ 30 _Upper Fant-road, Maidstone._

1891. ‡PARKER, WILLIAM NEWTON, Ph.D., F.Z.S., Professor of Biology in University College, Cardiff.

1899. *Parkin, John. Blaithwaite, Carlisle.

1879. *Parkin, William. The Mount, Sheffield.

1887. ‡Parkinson, James. Greystones, Langho, Blackburn.

1859. ‡Parkinson, Robert, Ph.D. Yewbarrow House, Grange-over-Sands.

1883. ‡Parson, T. Cooke, M.R.C.S. Atherston House, Clifton, Bristol.

1878. ‡PARSONS, Hon. C. A., F.R.S., M.Inst.C.E. Holeyn Hall, Wylam-on-Tyne.

1898. *Partridge, Miss Josephine M. Girton College, Cambridge.

1898. ‡Pass, Alfred C. Clifton Down, Bristol.

1887. ‡PATERSON, A. M., M.D., Professor of Anatomy in University College, Liverpool.

Year of Election.

1897. ‡Paterson, John A. 23 Walmer-road, Toronto, Canada.
1896. ‡Paton, A. A. Greenbank-drive, Wavertree, Liverpool.
1897. ‡PATON, D. NOËL, M.D. 33 George-square, Edinburgh.
1883. *Paton, Rev. Henry, M.A. 120 Polwarth-terrace, Edinburgh.
1884. *Paton, Hugh. Box 2400, Montreal, Canada.
1902. §Patterson, Robert, F.Z.S., M.R.I.A. Ivy Dene, Malone Park, Belfast.
1876. ‡Patterson, T. L. Maybank, Greenock.
1874. ‡Patterson, W. H., M.R.I.A. 26 High-street, Belfast.
1863. ‡PATTINSON, JOHN, F.C.S. 75 The Side, Newcastle-upon-Tyne.
1879. *Patzer, F. R. Clayton Lodge, Newcastle, Staffordshire.
1883. ‡Paul, George. 10 St. Mary's-avenue, Harrogate.
1892. ‡Paul, J. Balfour. 30 Heriot-row, Edinburgh.
1863. ‡PAVY, FREDERICK WILLIAM, M.D., F.R.S. 35 Grosvenor-street, W.
1887. *Paxman, James. Stisted Hall, near Braintree, Essex.
1887. *Payne, Miss Edith Annie. Hatchlands, Cuckfield, Hayward's Heath.
1881. ‡Payne, J. Buxton. 15 Mosley-street, Newcastle-upon-Tyne.
1877. *Payne, J. C. Charles. 1 Botanic-avenue, The Plains, Belfast.
1881. ‡Payne, Mrs. 1 Botanic-avenue, The Plains, Belfast.
1866. ‡Payne, Joseph F., M.D. 78 Wimpole-street, W.
1888. *Paynter, J. B. Hendford Manor House, Yeovil.
1886. ‡Payton, Henry. Wellington-road, Birmingham.
1876. ‡Peace, G. H. Monton Grange, Eccles, near Manchester.
1879. ‡Peace, William K. Moor Lodge, Sheffield.
1885. ‡PEACH, B. N., F.R.S., F.R.S.E., F.G.S. Geological Survey Office, Edinburgh.
1875. ‡Peacock, Thomas Francis. 12 South-square, Gray's Inn, W.C.
1886. *Pearce, Mrs. Horace. Orsett House, Birmingham-road, Kidderminster.
1886. ‡Pearsall, Howard D. 19 Willow-road, Hampstead, N.W.
1883. ‡Pearson, Arthur A. Colonial Office, S.W.
1891. ‡Pearson, B. Dowlais Hotel, Cardiff.
1893. *Pearson, Charles E. Hillcrest, Lowdham, Nottinghamshire.
1898. §Pearson, George. Bank-chambers, Baldwin-street, Bristol.
1883. ‡Pearson, Miss Helen E. Oakhurst, Birkdale, Southport.
1881. ‡Pearson, John. Glentworth House, The Mount, York.
1883. ‡Pearson, Mrs. Glentworth House, The Mount, York.
1872. **Pearson, Joseph. Grove Farm, Merlin, Raleigh, Ontario, Canada.*
1892. ‡Pearson, J. M. John Dickie-street, Kilmarnock.
1881. ‡Pearson, Richard. 57 Bootham, York.
1889. ‡Pease, Howard. Enfield Lodge, Benwell, Newcastle-upon-Tyne.
1863. ‡Pease, Sir Joseph W., Bart., M.P. Hutton Hall, near Guisborough.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
1855. *Peckover, Alexander, LL.D., F.S.A., F.L.S., F.R.G.S. Bank House, Wisbech, Cambridgeshire.
1888. ‡Peckover, Miss Alexandrina. Bank House, Wisbech, Cambridgeshire.
1885. ‡Peddie, William, D.Sc., F.R.S.E. 2 Cameron-park, Edinburgh.
1884. ‡Peebles, W. E. 9 North Frederick-street, Dublin.
1878. *Peek, William. 20 Brier-road, Fulham, S.W.
1901. *Peel, Hon. William, M.P. 13 King's Bench-walk, Temple, E.C.
1881. ‡Peggs, J. Wallace. 21 Queen Anne's-gate, S.W.
1878. ‡Pemberton, Charles Seaton. 44 Lincoln's Inn-fields, W.C.
1887. §PENDLEBURY, WILLIAM H., M.A., F.C.S. (Local Sec. 1899). 6 Gladstone-terrace, Priory Hill, Dover.
1894. §Pengelly, Miss. Lamorna, Torquay.
1897. ‡PENHALLOW, Professor D. P., M.A. McGill University, Montreal, Canada.

Year of Election.
1896. ‡Pennant, P. P. Nantlys, St. Asaph.
1898. ‡Pentecost, Harold, B.A. Clifton College, Bristol.
1889. ‡Percival, Archibald Stanley, M.A., M.B. 16 Ellison-place, Newcastle-upon-Tyne.
1898. ‡Percival, Francis W., M.A., F.R.G.S. 2 Southwick-place, W.
1895. ‡Percival, John, M.A., Professor of Botany in the South-Eastern Agricultural College, Wye, Kent.
*Perigal, Frederick. Lower Kingswood, Reigate.
1894. ‡PERKIN, A. G., F.R.S.E., F.C.S., F.I.C. 8 Montpelier-terrace, Hyde Park, Leeds.
1902. §Perkin, F. Mollwo. Bella Vista, Duddingston, Midlothian.
1868. *PERKIN, WILLIAM HENRY, Ph.D., LL.D., F.R.S., F.C.S. (Pres. B, 1876; Council 1880–86). The Chestnuts, Sudbury, Harrow, Middlesex.
1884. ‡PERKIN, WILLIAM HENRY, jun., LL.D., Ph.D., F.R.S., F.R.S.E. (Pres. B, 1900; Council 1901–). Professor of Organic Chemistry in the Owens College, Manchester. Fairview, Wilbraham-road, Fallowfield, Manchester.
1864. *Perkins, V. R. Wotton-under-Edge, Gloucestershire.
1898. *Perman, E. P. University College, Cardiff.
1885. ‡Perrin, Miss Emily. 31 St John's Wood Park, N.W.
1886. ‡Perrin, Henry S. 31 St. John's Wood Park, N.W.
1886. ‡Perrin, Mrs. 31 St. John's Wood Park, N.W.
1874. *PERRY, JOHN, M.E., D.Sc., F.R.S. (Pres. G, 1902; Council 1901–), Professor of Mechanics and Mathematics in the Royal College of Science, S.W.
1883. ‡Perry, Ottley L., F.R.G.S. Bolton-le-Moors, Lancashire.
1883. ‡Perry, Russell R. 34 Duke-street, Brighton.
1900. §Petavel, J. E. The Owens College, Manchester.
1897. ‡Peters, Dr. George A. 171 College-street, Toronto, Canada.
1898. ‡Pethick, William. Woodside, Stoke Bishop, Bristol.
1901. §Pethybridge, G. H. Museum of Science and Art, Dublin.
1883. ‡Petrie, Miss Isabella. Stone Hill, Rochdale.
1895. ‡PETRIE, W. M. FLINDERS, D.C.L., F.R.S. (Pres. H, 1895), Professor of Egyptology in University College, W.C.
1871. *Peyton, John E. H., F.R.A.S., F.G.S. 13 Fourth-avenue, Hove, Brighton.
1886. ‡Phelps, Major-General A. 23 Augustus-road, Edgbaston, Birmingham.
1863. *PHENÉ, JOHN SAMUEL, LL.D., F.S.A., F.G.S., F.R.G.S. 5 Carlton-terrace, Oakley-street, S.W.
1896. ‡Philip, George, jun. Weldon, Bidston, Cheshire.
1892. ‡Philip, R. W., M.D. 4 Melville-crescent, Edinburgh.
1870. ‡Philip, T. D. 51 South Castle-street, Liverpool.
1853. *Philips, Rev. Edward. Hollington, Uttoxeter, Staffordshire.
1853. *Philips, Herbert. The Oak House, Macclesfield.
1877. §Philips, T. Wishart. Elizabeth Lodge, George-lane, Woodford, Essex
1863. ‡Philipson, Sir G. H. 7 Eldon-square, Newcastle-upon-Tyne.
1883. ‡Phillips, Arthur G. 20 Canning-street, Liverpool.
1899. ‡Phillips, Charles E. S. Castle House, Shooter's Hill, Kent.
1894. ‡Phillips, Staff-Commander E. C. D., R.N., F.R.G.S. 14 Hargreaves-buildings, Chapel-street, Liverpool.
1887. ‡*Phillips, H. Harcourt, F.C.S.* 183 *Moss-lane East, Manchester.*
1902. §Phillips, J. St. J., B.E. 64 Royal-avenue, Belfast.
1890. ‡Phillips, R. W., M.A., D.Sc., Professor of Biology in University College, Bangor.

Year of Election.
1883. ‡Phillips, S. Rees. Wonford House, Exeter.
1881. ‡Phillips, William. 9 Bootham-terrace, York.
1898. ‡Philps, Captain Lambe. 7 Royal-terrace, Weston-super-Mare.
1884. *Pickard, Rev. H. Adair, M.A. Airedale, Oxford.
1883. *Pickard, Joseph William. Oatlands, Lancaster.
1901. §Pickard, Robert H., D.Sc. Isca, Merlin-road, Blackburn.
1894. ‡PICKARD-CAMBRIDGE, Rev. O., M.A., F.R.S. Bloxworth Rectory, Wareham.
1885. *PICKERING, SPENCER P. U., M.A., F.R.S. Harpenden, Herts.
1884. *Pickett, Thomas E., M.D. Maysville, Mason Co., Kentucky, U.S.A.
1888. *Pidgeon, W. R. 42 Porchester-square, W.
1871. ‡*Pigot, Thomas F., M.R.I.A. Royal College of Science, Dublin.*
1884. ‡Pike, L. G., M.A., F.Z.S. 12 King's Bench-walk, Temple, E.C.
1865. ‡PIKE, L. OWEN. 4A Marlborough-gate, Hyde Park, W.
1873. ‡Pike, W. H., M.A., Ph.D. Toronto, Canada.
1896. *Pilkington, A. C. The Hazels, Prescot, Lancashire.
1896. *Pilling, William. Rosario, Heene-road, West Worthing.
1877. ‡Pim, Joseph T. Greenbank, Monkstown, Co. Dublin.
1868. ‡*Pinder, T. R. St. Andrew's, Norwich.*
1876. ‡PIRIE, Rev. G., M.A. (Local Sec. 1885), Professor of Mathematics in the University of Aberdeen. 33 College Bounds, Old Aberdeen.
1887. ‡Pitkin, James. 56 Red Lion-street, Clerkenwell, E.C.
1875. ‡Pitman, John. Redcliff Hill, Bristol.
1883. ‡*Pitt, George Newton, M.A., M.D. 24 St. Thomas-street, Borough, S.E.*
1883. ‡Pitt, Sydney. 16 St. Andrew's-street, Holborn-circus, E.C.
1893. *PITT, WALTER, M.Inst.C.E. South Stoke House, near Bath.
1900. *Platts, Walter. Fairmount, Bingley.
1884. *Playfair, W. S., M.D., LL.D., Professor of Midwifery in King's College, London. 38 Grosvenor-street, W.
1898. ‡Playne, H. C. 28 College-road, Clifton, Bristol.
1893. ‡Plowright, Henry J. Brampton Foundries, Chesterfield.
1897. ‡Plummer, J. H. Bank of Commerce, Toronto, Canada.
1898. §Plummer, W. E., M.A., F.R.A.S. The Observatory, Bidston, Birkenhead.
1899. ‡Plumptre, Fitzwalter. Goodnestone, Dover.
1857. ‡Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Queen's Co., Ireland.
1900. *Pocklington, H. Cabourn. 41 Virginia-road, Leeds.
1881. §Pocklington, Henry. 20 Park-row, Leeds.
1888. ‡*Pocock, Rev. Francis. 4 Brunswick-place, Bath.*
1896. ‡Pollard, James. High Down, Hitchin, Herts.
1898. ‡POLLEN, Rev. G. C. H., F.G.S. Stonyhurst College, Blackburn.
1896. *Pollex, Albert. Tenby House, Egerton Park, Rockferry.
1862. *Polwhele, Thomas Roxburgh, M.A., F.G.S. Polwhele, Truro, Cornwall.
1891. ‡Pomeroy, Captain Ralph. 201 Newport-road, Cardiff.
1900. §POPE, W. J., F.R.S. 48 Cawdor-road, Fallowfield, Manchester.
1892. ‡Popplewell, W. C., M.Sc., Assoc.M.Inst.C.E. The Yew, Marple, near Stockport.
1868. ‡PORTAL, Sir WYNDHAM S., Bart. Malshanger, Basingstoke.
1901. §Porter, Dr. Alfred W., B.Sc. 87 Parliament Hill-mansions, Lissenden-gardens, N.W.
1883. *Porter, Rev. C. T., LL.D., D.D. All Saints' Vicarage, Southport.
1883. ‡Postgate, Professor J. P., M.A. University College, Gower-street, W.C.
1887. ‡Potter, Edmund P. Hollinhurst, Bolton.

Year of Election.

1883. ‡Potter, M. C., M.A., F.L.S., Professor of Botany in the College of Science, Newcastle-upon-Tyne. 14 Highbury, Newcastle-upon-Tyne.
1886. *POULTON, EDWARD B., M.A., F.R.S., F.L.S., F.G.S., F.Z.S. (Pres. D, 1896; Council 1895–1901), Professor of Zoology in the University of Oxford. Wykeham House, Banbury-road, Oxford.
1898. *Poulton, Edward Palmer. Wykeham House, Banbury-road, Oxford.
1873. *Powell, Sir Francis S., Bart., M.P., F.R.G.S. Horton Old Hall, Yorkshire; and 1 Cambridge-square, W.
1887. *Powell, Horatio Gibbs., F.R.G.S. Wood Villa, Tettenhall Wood, Wolverhampton.
1883. ‡Powell, John. Brynmill-crescent, Swansea.
1894. *Powell, Sir Richard Douglas, Bart., M.D. 62 Wimpole-street, Cavendish-square, W.
1875. ‡Powell, William Augustus Frederick. Norland House, Clifton, Bristol.
1887. §Pownall, George H. 20 Birchin-lane, E.C.
1867. ‡Powrie, James. Reswallie, Forfar.
1883. ‡POYNTING, J. H., D.Sc., F.R.S. (Pres. A, 1899), Professor of Physics in the University, Birmingham. 10 Ampton-road, Edgbaston, Birmingham.
1884. *Prankerd, A. A., D.C.L. 66 Banbury-road, Oxford.
1869. *PREECE, Sir WILLIAM HENRY, K.C.B., F.R.S., M.Inst.C.E. (Pres. G, 1888; Council 1888–95, 1896–1902). Gothic Lodge, Wimbledon Common, Surrey; and 8 Queen Anne's-gate, S.W.
1888. *Preece, W. Llewellyn. Bryn Helen, Woodborough-road, Putney, S.W.
1892. §Prentice, Thomas. Willow Park, Greenock.
1889. §Preston, Alfred Eley, M.Inst.C.E., F.G.S. 14 The Exchange, Bradford, Yorkshire.
1894. ‡Preston, Arthur E. Piccadilly, Abingdon, Berkshire.
1893. *Preston, Martin Inett. 48 Ropewalk, Nottingham.
1884. *Prevost, Major L. de T., 2nd Battalion Argyll and Sutherland Highlanders.
Price, J. T. Neath Abbey, Glamorganshire.
1888. ‡PRICE, L. L. F. R., M.A., F.S.S. (Pres. F, 1895; Council, 1898–). Oriel College, Oxford.
1875. *Price, Rees. 163 Bath-street, Glasgow.
1891. ‡Price, William. 40 Park-place, Cardiff.
1897. *Price, W. A., M.A. The Mill House, Broomfield, Chelmsford.
1897. ‡Primrose, Dr Alexander. 196 Simcoe-street, Toronto, Canada.
1892. ‡Prince, Professor Edward E., B.A. Ottawa, Canada.
1864. *Prior, R. C. A., M.D. 48 York-terrace, Regent's Park, N.W.
1889. *Pritchard, Eric Law, M.D., M.R.C.S. 70 Fairhazel-gardens, South Hampstead, N.W.
1876. *PRITCHARD, URBAN, M.D., F.R.C.S. 26 Wimpole-street, W.
1888. ‡Probyn, Leslie C. 79 Onslow-square, S.W.
1881. §Procter, John William. Ashcroft, York.
1863. ‡Proctor, R. S. Grey-street, Newcastle-upon-Tyne.
Proctor, William. Elmhurst, Higher Erith-road, Torquay.
1884. *Proudfoot, Alexander, M.D. 100 State-street, Chicago, U.S.A.
1879. *Prouse, Oswald Milton, F.G.S. Alvington, Ilfracombe.
1872. *Pryor, M. Robert. Weston Park, Stevenage, Herts.
1871. *Puckle, Rev. T. J. Chestnut House, Huntingdon-road, Cambridge.
1873. ‡Pullan, Lawrence. Bridge of Allan, N.B.
1867. *Pullar, Sir Robert, F.R.S.E. Tayside, Perth.
1883. *Pullar, Rufus D., F.C.S. Brahan, Perth.

Year of Election.
1891. ‡Pullen, W. W. F. University College, Cardiff.
1887. §**PUMPHREY, WILLIAM** (Local Sec. 1888). 2 Oakland-road, Redland, Bristol.
1885. ‡**PURDIE, THOMAS**, B.Sc., Ph.D., F.R.S., Professor of Chemistry in the University of St. Andrews. 14 South-street, St. Andrews, N.B.
1852. ‡Purdon, Thomas Henry, M.D. Belfast.
1881. ‡Purey-Cust, Very Rev. Arthur Percival, M.A., Dean of York. The Deanery, York.
1874. ‡**PURSER, FREDERICK**, M.A. Rathmines Castle, Dublin.
1866. ‡**PURSER**, Professor **JOHN**, M.A., LL.D., M.R.I.A. (Pres. A, 1902). Rathmines Castle, Dublin.
1878. ‡Purser, John Mallet. 3 Wilton-terrace, Dublin.
1884. *Purves, W. Laidlaw. 20 Stratford-place, Oxford-street, W.
1860. *Pusey, S. E. B. Bouverie. Pusey House, Faringdon.
1898. *Pye, Miss E. St. Mary's Hall, Rochester.
1883. §Pye-Smith, Arnold. Willesley, Park Hill Rise, Croydon.
1883. ‡Pye-Smith, Mrs. Willesley, Park Hill Rise, Croydon.
1868. ‡**PYE-SMITH**, P. H., M.D., F.R.S. 48 Brook-street, W.; and Guy's Hospital, S.E.
1879. ‡Pye-Smith, R. J. 350 Glossop-road, Sheffield.

1893. ‡Quick, James. University College, Bristol.
1894. ‡Quick, Professor W. J. University of Missouri, Columbia, U.S.A.

1870. ‡Rabbits, W. T. 6 Cadogan-gardens, S.W.
1870. ‡*Radcliffe, D. R. Phœnix Safe Works, Windsor, Liverpool.*
1896. §Radcliffe, Herbert. Balderstone Hall, Rochdale.
1855. *Radstock, The Right Hon. Lord. Mayfield, Woolston, Southampton.
1887. *Ragdale, John Rowland. The Beeches, Strand, near Manchester.
1864. ‡*Rainey, James T. 3 Kent-gardens, Ealing, W.*
1898. *Raisin, Miss Catherine A., D.Sc. Bedford College, York-place, Baker-street, W.
1896. ***RAMAGE, HUGH.** St. John's College, Cambridge.
1894. ***RAMBAUT, ARTHUR A.**, M.A., D.Sc., F.R.S., F.R.A.S., M.R.I.A. Radcliffe Observatory, Oxford.
1863. ‡**RAMSAY, ALEXANDER.** 2 Cowper-road, Acton, Middlesex, W.
1884. ‡Ramsay, George G., LL.D., Professor of Humanity in the University of Glasgow. 6 The College, Glasgow.
1884. ‡Ramsay, Mrs. G. G. 6 The College, Glasgow.
1861. ‡Ramsay, John. Kildalton, Argyllshire.
1885. ‡Ramsay, Major. Straloch, N.B.
1889. ‡Ramsay, Major R. G. W. Bonnyrigg, Edinburgh.
1876. ***RAMSAY, Sir WILLIAM**, K.C.B., Ph.D., F.R.S. (Pres. B, 1897; Council 1891–98), Professor of Chemistry in University College, London. 12 Arundel-gardens, W.
1883. ‡Ramsay, Lady. 12 Arundel-gardens, W.
1869. *Rance, H. W. Henniker, LL.D. 10 Castletown-road, West Kensington, W.
1901. ‡Rankin, James, M.A., B.Sc. The University, Glasgow.
1868. *Ransom, Edwin, F.R.G.S. 24 Ashburnham-road, Bedford.
1893. ‡Ransom, W. B., M.D. The Pavement, Nottingham.
1863. ‡**RANSOM, WILLIAM HENRY**, M.D., F.R.S. The Pavement, Nottingham.
1861. ‡**RANSOME, ARTHUR**, M.A., M.D., F.R.S. (Local Sec. 1861). Sunnyhurst, Deane Park, Bournemouth.
Ransome, Thomas. Hest Bank, near Lancaster.

Year of Election.
1889. §Rapkin, J. B. Thrale Hall, Streatham, S.W.
Rashleigh, Jonathan. 3 Cumberland-terrace, Regent's Park, N.W.
1864. ‡Rate, Rev. John, M.A. Fairfield, East Twickenham.
1892. *Rathbone, Miss May. Backwood, Neston, Cheshire.
1874. ‡RAVENSTEIN, E. G., F.R.G.S., F.S.S. (Pres. E, 1891). 2 York-mansions, Battersea Park, S.W.
1889. ‡Rawlings, Edward. Richmond House, Wimbledon Common, Surrey.
1870. ‡Rawlins, G. W. The Hollies, Rainhill, Liverpool.
1887. ‡Rawson, Harry. Earlswood, Ellesmere Park, Eccles, Manchester.
1886. ‡*Rawson, W. Stepney, M.A. 68 Cornwall-gardens, Queen's Gate, S.W.*
1868. *RAYLEIGH, The Right Hon. Lord, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. (PRESIDENT, 1884; TRUSTEE, 1883– : Pres. A, 1882; Council, 1878–83), Professor of Natural Philosophy in the Royal Institution. Terling Place, Witham, Essex.
1895. ‡Raynbird, Hugh, jun. Garrison Gateway Cottage, Old Basing, Basingstoke.
1883. *Rayne, Charles A., M.D., M.R.C.S. St. Mary's Gate, Lancaster.
1897. *Rayner, Edwin Hartree. Teviot Dale, Stockport.
1896. *READ, CHARLES H., F.S.A. (Pres. H, 1899). British Museum, W.C.
1902. §Reade, R. H. Wilmount, Dunmurry.
1870. ‡READE, THOMAS MELLARD, F.G.S. Blundellsands, Liverpool.
1884. §Readman, J. B., D.Sc., F.R.S.E. 4 Lindsay-place, Edinburgh.
1899. ‡Reaster, James William. 68 Linden-grove, Nunhead, S.E.
1852. *REDFERN, Professor PETER, M.D. (Pres. D, 1874). 4 Lower-crescent, Belfast.
1892. ‡Redgrave, Gilbert R., Assoc.Inst.C.E. The Elms, Westgate-road, Beckenham, Kent.
1889. ‡Redmayne, J M. Harewood, Gateshead.
1889. ‡Redmayne, Norman. 26 Grey-street, Newcastle-upon-Tyne.
1890. *Redwood, Boverton, F.R.S.E., F.C.S. Glen Wathen, Church End, Finchley, N.
1861. ‡REED, Sir EDWARD JAMES, K.C.B., F.R.S. Broadway-chambers, Westminster, S.W.
1889. ‡Reed, Rev. George. Bellingham Vicarage, Bardon Mill, Carlisle.
1891. *Reed, Thomas A. Bute Docks, Cardiff.
1894. *Rees, Edmund S. G. Dunscar, Oaken, near Wolverhampton.
1891. *Rees, I. Treharne, M.Inst.C.E. Hightield, Penarth.
1888. ‡Rees, W. L. 11 North-crescent, Bedford-square, W.C.
1875. ‡Rees-Mogg, W. Wooldridge. Cholwell House, near Bristol.
1897. ‡Reeve, Richard A. 22 Shuter-street, Toronto, Canada.
1901. *Reid, Andrew T. 10 Woodside-terrace, Glasgow.
1881. §Reid, Arthur S., M.A., F.G.S. Trinity College, Glenalmond, N.B.
1883. *REID, CLEMENT, F.R.S., F.L.S., F.G.S. 28 Jermyn-street, S.W.
1892. ‡REID, E. WAYMOUTH, B.A., M.B., F.R.S., Professor of Physiology in University College, Dundee.
1889. ‡Reid, G., Belgian Consul. Leazes House, Newcastle-upon-Tyne.
1901. *Reid, Hugh. Belmont, Springburn, Glasgow.
1876. ‡Reid, James. 10 Woodside-terrace, Glasgow.
1901. §Reid, John. 7 Park-terrace, Glasgow.
1897. §Reid, T. Whitehead, M.D. St. George's House, Canterbury.
1892. ‡Reid, Thomas. University College, Dundee.
1887. *Reid, Walter Francis. Fieldside, Addlestone, Surrey.
1893. ‡Reinach, Baron Albert von. Frankfort s. M., Prussia.
1875. §REINOLD, A. W., M.A., F.R.S. (Council 1890–95), Professor of Physics in the Royal Naval College, Greenwich, S.E.
1863. ‡RENALS, E. 'Nottingham Express' Office, Nottingham.

Year of Election.

1894. ‡RENDALL, Rev. G. H., M.A. Charterhouse, Godalming.
1891. *Rendell, Rev. James Robson, B.A. Whinside, Whalley-road, Accrington.
1885. ‡Rennett, Dr. 12 Golden-square, Aberdeen.
1889. *Rennie, George B. 20 Lowndes-street, S.W.
1867. ‡*Renny, W. W. 8 Douglas-terrace, Broughty Ferry, Dundee.*
1883. *Reynolds, A. H. Bank House, 135 Lord-street, Southport.
1871. ‡REYNOLDS, JAMES EMERSON, M.D., D.Sc., F.R.S., Pres.C.S., M.R.I.A. (Pres. B, 1893; Council 1893–99), Professor of Chemistry in the University of Dublin. The Laboratory, Trinity College, Dublin.
1900. *Reynolds, Miss K. M. 4 Colinette-road, Putney, S.W.
1870. *REYNOLDS, OSBORNE, M.A., LL.D., F.R.S., M.Inst.C.E. (Pres. G, 1887), Professor of Engineering in the Owens College, Manchester. 19 Lady Barn-road, Fallowfield, Manchester.
1896. ‡Reynolds, Richard S. 73 Smithdown-lane, Liverpool.
1896. ‡Rhodes, Albert. Fieldhurst, Liversidge, Yorkshire.
1877. *Rhodes, John. 360 Blackburn-road, Accrington, Lancashire.
1890. ‡Rhodes, J. M., M.D. Ivy Lodge, Didsbury.
1884. ‡Rhodes, Lieut.-Colonel William. Quebec, Canada.
1899. *RHYS, Professor JOHN, D.Sc. (Pres. H, 1900). Jesus College, Oxford.
1877. *Riccardi, Dr. Paul, Secretary of the Society of Naturalists. Riva Muro, 14, Modena, Italy.
1891. ‡Richards, D. 1 St. Andrew's-crescent, Cardiff.
1891. ‡Richards, H. M. 1 St. Andrew's-crescent, Cardiff.
1889. ‡Richards, Professor T. W., Ph.D. Cambridge, Massachusetts, U.S.A.
1869. *Richardson, Charles. 6 The Avenue, Bedford Park, Chiswick, W.
1882. ‡Richardson, Rev. George, M.A. Walcote, Winchester.
1884. *Richardson, George Straker. Isthmian Club, Piccadilly, W.
1889. ‡Richardson, Hugh, M.A. Bootham School, York.
1884. *Richardson, J. Clarke. Derwen Fawr, Swansea.
1896. *Richardson, Nelson Moore, B.A., F.E.S. Montevideo, Chickerell, near Weymouth.
1901. *Richardson, Owen Willans. Victoria-crescent, Dewsbury.
1870. ‡Richardson, Ralph, F.R.S.E. 10 Magdala-place, Edinburgh.
1889. ‡Richardson, Thomas, J.P. 7 Windsor-terrace, Newcastle-upon-Tyne.
1876. §Richardson, William Haden. City Glass Works, Glasgow.
1891. ‡Riches, Carlton H. 21 Dumfries-place, Cardiff.
1891. §Riches, T. Harry. 8 Park-grove, Cardiff.
1886. ‡Richmond, Robert. Heathwood, Leighton Buzzard.
1868. ‡RICKETTS, CHARLES, M.D., F.G.S. Curdridge, Botley, Hampshire.
*RIDDELL, Major-General CHARLES J. BUCHANAN, C.B., R.A., F.R.S. Oaklands, Chudleigh, Devon.
1883. *RIDEAL, SAMUEL, D.Sc., F.C.S. 28 Victoria-street, S.W.
1902. §Ridgeway, William, M.A., Professor of Archæology in the University of Cambridge. Fen Ditton, Cambridge.
1894. §RIDLEY, E. P. (Local Sec. 1895). Burwood, Westerfield-road, Ipswich.
1861. ‡Ridley, John. 19 Belsize-park, Hampstead, N.W.
1884. ‡Ridout, Thomas. Ottawa, Canada.
1881. *Rigg, Arthur. 15 Westbourne Park-villas, W.
1883. *RIGG, EDWARD, M.A. Royal Mint, E.
1892. ‡Rintoul, D., M.A. Clifton College, Bristol.
1873. ‡Ripley, Sir Edward, Bart. Acacia, Apperley, near Leeds.
*RIPON, The Most Hon. the Marquess of, K.G., G.C.S.I., C.I.E., D.C.L., F.R.S., F.L.S., F.R.G.S. 9 Chelsea Embankment, S.W.

Year of Election.

1892. ‡Ritchie, R. Peel, M.D., F.R.S.E. 1 Melville-crescent, Edinburgh.
1889. ‡Ritson, U. A. 1 Jesmond-gardens, Newcastle-upon-Tyne.
1900. ‡Rixon, F. W., B.Sc. 79 Green-lane, Heywood, Lancashire.
1898. §Robb, Alfred A. Lisnabreeny House, Belfast.
1902. *Roberts, Bruno. 30 St. George's-square, Regent's Park, N.W.
1887. *Roberts, Evan. 30 St. George's-square, Regent's Park, N.W.
1859. ‡Roberts, George Christopher. Hull.
1870. *ROBERTS, ISAAC, D.Sc., F.R.S., F.R.A.S., F.G.S. Starfield, Crowborough, Sussex.
1894. *Roberts, Miss Janora. 14 Alexandra-road, Southport.
1881. ‡Roberts, R. D., M.A., D.Sc., F.G.S. 4 Regent-street, Cambridge.
1879. ‡Roberts, Samuel, M.P. The Towers, Sheffield.
1879. ‡Roberts, Samuel, jun. The Towers, Sheffield.
1896. §Roberts, Thomas J. 33 Serpentine-road, Liscard, Cheshire.
1883. ‡Robertson, Alexander. Montreal, Canada.
1884. ‡Robertson, E. Stanley, M.A. 43 Waterloo-road, Dublin.
1883. ‡Robertson, George H. Plas Newydd, Llangollen.
1883. ‡Robertson, Mrs. George H. Plas Newydd, Llangollen.
1897. §ROBERTSON, Sir GEORGE S., K.C.S.I. (Pres. E, 1900). 1 Pump-court, Temple, E.C.
1897. §Robertson, Professor J. W. Department of Agriculture, Ottawa, Canada.
1901. *Robertson, Robert, B.Sc., M.Inst.C.E. 154 West George-street, Glasgow.
1892. ‡Robertson, W. W. 3 Parliament-square, Edinburgh.
1886. **Robinson, C. R. 27 Elvetham-road, Birmingham.*
1898. §Robinson, Charles E., M.Inst.C.E. Holm Cross, Ashburton, South Devon.
1861. ‡Robinson, Enoch. Dukinfield, Ashton-under-Lyne.
1897. ‡Robinson, Haynes. St. Giles's Plain, Norwich.
1887. §Robinson, Henry, M.Inst.C.E. 13 Victoria-street, S.W.
1902. §Robinson, Herbert C. Holmfield, Aigburth, Liverpool.
1902. §Robinson, James, M.A., F.R.G.S. Dulwich College, Dulwich, S.E.
1901. §Robinson, John, M.Inst.C.E. 8 Vicarage-terrace, Kendal.
1863. ‡Robinson, J. H. 6 Montallo-terrace, Barnard Castle.
1878. ‡Robinson, John L. 198 Great Brunswick-street, Dublin.
1895. *Robinson, Joseph Johnson. 8 Trafalgar-road, Birkdale, Southport.
1876. ‡Robinson, M. E. 6 Park-circus, Glasgow.
1899. *Robinson, Mark, M.Inst.C.E. Overslade, Bilton, near Rugby.
1887. ‡Robinson, Richard. Bellfield Mill, Rochdale.
1881. ‡Robinson, Richard Atkinson. 195 Brompton-road, S.W.
1875. *Robinson, Robert, M.Inst.C.E. Beechwood, Darlington.
1884. ‡Robinson, Stillman. Columbus, Ohio, U.S.A.
1901. ‡Robinson, T. Eaton. 33 Cecil-street West, Glasgow.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1891. ‡Robinson, William, Assoc.M.Inst.C.E., Professor of Engineering in University College, Nottingham.
1888. ‡Robottom, Arthur. 3 St. Alban's-villas, Highgate-road, N.W.
1870. *Robson, E. R. Palace Chambers, 9 Bridge-street, Westminster, S.W.
1872. *Robson, William. 5 Gillsland-road, Merchiston, Edinburgh.
1890. ‡Rochester, The Right Rev. E. S. Talbot, D.D., Lord Bishop of. Kennington Park, S.E.
1896. ‡*Rock, W. H. 73 Park-road East, Birkenhead.*
1896. ‡Rodger, Alexander M. The Museum, Tay Street, Perth.
1885. *Rodger, Edward. 1 Clairmont-gardens, Glasgow.

Year of Election.

1885. *Rodriguez, Epifanio. New Adelphi Chambers, 6 Robert-street, Adelphi, W.C.
1866. ‡Roe, Sir Thomas. Grove-villas, Litchurch.
1898. ‡ROGERS, BERTRAM, M.D. (Local Sec. 1898.) 11 York-place, Clifton, Bristol.
1867. ‡Rogers, James S. Rosemill, by Dundee.
1890. *Rogers, L. J., M.A., Professor of Mathematics in Yorkshire College, Leeds. 15 Regent Park-avenue, Leeds.
1883. ‡Rogers, Major R. Alma House, Cheltenham.
1882. §Rogers, Rev. Canon Saltren, M.A. Tresleigh, St. Austell, Cornwall.
1884. *Rogers, Walter. Hill House, St. Leonards.
1889. ‡Rogerson, John. Croxdale Hall, Durham.
1897. ‡Rogerson, John. Barrie, Ontario, Canada.
1876. ‡ROLLIT, Sir A. K., M.P., B.A., LL.D., D.C.L., F.R.A.S., Hon. Fellow K.C.L. Thwaite House, Cottingham, East Yorkshire.
1891. ‡Rönnfeldt, W. 43 Park-place, Cardiff.
1894. *Rooper, T. Godolphin. 12 Cumberland-place, Southampton.
1881. *Roper, W. O. Beechfield, Yealand Conyers, Carnforth.
1855. *ROSCOE, Sir HENRY ENFIELD, B.A., Ph.D., LL.D., D.C.L., F.R.S. (PRESIDENT, 1887; Pres. B, 1870, 1884; Council 1874–81; Local Sec. 1861; VICE-PRESIDENT, 1903). 10 Bramham-gardens, S.W.
1883. *Rose, J. Holland, M.A. 11 Endlesham-road, Balham, S.W.
1894. *ROSE, T. K., D.Sc, Chemist and Assayer to the Royal Mint. Royal Mint, E.
1900. §Rosenhain, Walter, B.A. 185 Monument-road, Edgbaston, Birmingham.
1885. ‡Ross, Alexander. Riverfield, Inverness.
1887. ‡Ross, Edward. Marple, Cheshire.
1859. *Ross, Rev. James Coulman. Wadworth Hall, Doncaster.
1902. §Ross, John Callender. 46 Holland-street, Campden Hill, W.
1901. ‡Ross, Major RONALD, C.B., F.R.S. 36 Bentley-road, Liverpool.
1869. *ROSSE, The Right Hon. the Earl of, K.P., B.A., D.C.L., LL.D., F.R.S., F.R.A.S., M.R.I.A. Birr Castle, Parsonstown, Ireland.
1891. *Roth, H. Ling. 32 Prescot-street, Halifax, Yorkshire.
1893. ‡Rothera, G. B. Sherwood Rise, Nottingham.
1865. *Rothera, George Bell. Hazlewood, Forest Grove, Nottingham.
1901. *Rottenburg, Paul, LL.D. Care of Messrs. Leister, Bock, & Co., Glasgow.
1899. *Round, J. C., M.R.C.S. 19 Crescent-road, Sydenham Hill, S.E.
1884. *Rouse, M. L. Hollybank, Hayne Road, Beckenham.
1901. ‡Rouse, W. H. D. Perse School, Cambridge.
1861. ‡ROUTH, EDWARD J., M.A., D.Sc., F.R.S., F.R.A.S., F.G.S. St. Peter's College, Cambridge.
1883. ‡Rowan, Frederick John. 134 St. Vincent-street, Glasgow.
1865. ‡*Rowe, Rev. John. 13 Hampton-road, Forest Gate, Essex.*
1877. ‡ROWE, J. BROOKING, F.L.S., F.S.A. 16 Lockyer-street, Plymouth.
1890. ‡Rowley, Walter, F.S.A. Alderhill, Meanwood, Leeds.
1881. *ROWNTREE, JOHN S. Mount Villas, York.
1881. *Rowntree, Joseph. 38 St. Mary's, York.
1876. ‡Roxburgh, John. 7 Royal Bank-terrace, Glasgow.
1885. ‡Roy, John. 33 Belvidere-street, Aberdeen.
1899. ‡Rubie, G. S. Belgrave House, Folkestone-road, Dover.
1875. *RÜCKER, Sir A. W., M.A., D.Sc., F.R.S., Principal of the University of London (PRESIDENT, 1901; TRUSTEE, 1898– ; TREASURER, 1891–98; Pres. A, 1894; Council 1888–91). 19 Gledhow-gardens, South Kensington, S.W.

Year of Election.
1892. §Rücker, Mrs. Levetleigh, Dane-road, St. Leonards-on-Sea.
1869. §RUDLER, F. W., F.G.S. 18 St. George's-road, Kilburn, N.W.
1901. *Rudorf, C. C. G. 26 Weston-park, Crouch End, N.
1882. ‡Rumball, Thomas, M.Inst.C.E. 1 Victoria-villas, Brondesbury, N.W.
1896. *Rundell, T. W., F.R.Met.Soc. 25 Castle-street, Liverpool.
1887. ‡Ruscoe, John. Ferndale, Gee Cross, near Manchester.
1889. ‡Russell, The Right Hon. Earl. Amberley Cottage, Maidenhead.
1875. *Russell, The Hon. F. A. R. Dunrozel, Haslemere.
1884. ‡Russell, George. 13 Church-road, Upper Norwood, S.E.
Russell, John. 39 Mountjoy-square, Dublin.
1890. ‡Russell, Sir J. A., LL.D. Woodville, Canaan-lane, Edinburgh.
1883. *Russell, J. W. 16 Bardwell-road, Oxford.
1852. *Russell, Norman Scott. Arts Club, Dover-street, W.
1876. ‡Russell, Robert, F.G.S. 1 Sea View, St. Bees, Carnforth.
1886. ‡Russell, Thomas H. 3 Newhall-street, Birmingham.
1852. *RUSSELL, WILLIAM J., Ph.D., F.R.S., V.P.C.S. (Pres. B, 1873; Council 1873–80). 34 Upper Hamilton-terrace, St. John's Wood, N.W.
1886. ‡Rust, Arthur. Eversleigh, Leicester.
1897. ‡Rutherford, A. Toronto, Canada.
1891. ‡*Rutherford, George. Dulwich House. Pencisely-road, Cardiff.*
1887. ‡Rutherford, William. 7 Vine-grove, Chapman-street, Hulme, Manchester.
1889. ‡Ryder, W. J. H. 52 Jesmond-road, Newcastle-upon-Tyne.
1897. ‡Ryerson, G. S., M.D. Toronto, Canada.
1898. §Ryland, C. J. Southerndon House, Clifton, Bristol.
1865. †Ryland, Thomas. The Redlands, Erdington, Birmingham.

1883. ‡Sadler, Robert. 7 Lulworth-road, Birkdale, Southport.
1871. ‡Sadler, Samuel Champernowne. 186 Aldersgate-street, E.C.
1893. ‡SALISBURY, The Most Hon. the Marquis of, K.G., D.C.L., F.R.S. (PRESIDENT, 1894). 20 Arlington-street, S.W.
1881. ‡Salkeld, William. 4 Paradise-terrace, Darlington.
1857. ‡SALMON, Rev. GEORGE, D.D., D.C.L., LL.D., F.R.S. (Pres. A, 1878), Provost of Trinity College, Dublin.
1873. *Salomons, Sir David, Bart., F.G.S. Broomhill, Tunbridge Wells.
1887. ‡Samson, C. L. Carmona, Kersal, Manchester.
1861. *Samson, Henry. 6 St. Peter's-square, Manchester.
1901. §Samuel, John S. City Chambers, Glasgow.
1894. ‡SAMUELSON, The Right Hon. Sir BERNHARD, Bart., F.R.S., M.Inst.C.E. 56 Prince's-gate, S.W.
1883. ‡Sanderson, Surgeon-General Alfred. East India United Service Club, St. James's-square, S.W.
1893. ‡Sanderson, F. W., M.A. The School, Oundle.
1872. §SANDERSON, Sir J. S. BURDON, Bart., M.D., D.Sc., LL.D., D.C.L., F.R.S., F.R.S.E. (PRESIDENT, 1893; Pres. D, 1889; Council 1877–84), Regius Professor of Medicine in the University of Oxford. 64 Banbury-road, Oxford.
1883. ‡Sanderson, Lady Burdon. 64 Banbury-road, Oxford.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1896. §Saner, John Arthur, Assoc.M.Inst.C.E. Hightfield, Northwich.
1896. ‡Saner, Mrs. Highfield, Northwich.
1892. §Sang, William D. Tylehurst, Kirkcaldy, Fife.
1886. §Sankey, Percy E. 44 Russell-square, W.C.

Year of
Election.

1896. *Sargant, Miss Ethel. Quarry Hill, Reigate.
1896. ‡Sargant, W. L. Quarry Hill, Reigate.
1901. ‡Sarruf, N. Y. 'Al Mokattam,' Cairo.
1886. ‡Sauborn, John Wentworth. Albion, New York, U.S.A.
1886. ‡Saundby, Robert, M.D. 83A Edmund-street, Birmingham.
1900. *Saunder, S. A. Fir Holt, Crowthorne, Berks.
1868. ‡Saunders, A., M.Inst.C.E. King's Lynn.
1886. ‡Saunders, C. T. Temple-row, Birmingham.
1881. ‡SAUNDERS, HOWARD, F.L.S., F.Z.S. 7 Radnor-place, W.
1883. ‡Saunders, Rev. J. C. Cambridge.
1846. ‡SAUNDERS, TRELAWNEY W., F.R.G.S. 3 Elmfield on the Knowles, Newton Abbot, Devon.
1884. ‡SAUNDERS, Dr. WILLIAM. Experimental Farm, Ottawa, Canada.
1891. ‡*Saunders, W. H. R. Llanishen, Cardiff.*
1884. ‡Saunderson, C. E. 26 St. Famille-street, Montreal, Canada.
1887. ‡Savage, Rev. Canon E. B., M.A., F.S.A. St. Thomas' Vicarage, Douglas, Isle of Man.
1883. ‡Savage, W. W. 109 St. James's-street, Brighton.
1883. ‡Savery, G. M., M.A. The College, Harrogate.
1901. §Sawers, W. D. 1 Athole Gardens-place, Glasgow.
1887. §SAYCE, Rev. A. H., M.A., D.D. (Pres. H, 1887), Professor of Assyriology in the University of Oxford. Queen's College, Oxford.
1884. ‡Sayre, Robert H. Bethlehem, Pennsylvania, U.S.A.
1883. *Scarborough, George. Whinney Field, Halifax, Yorkshire.
1879. *SCHÄFER, E. A., LL.D., F.R.S., M.R.C.S. (GEN. SEC. 1895–1900; Pres. I, 1894; Council 1887–93), Professor of Physiology in the University of Edinburgh.
1888. *SCHARFF, ROBERT F., Ph.D., B.Sc., Keeper of the Natural History Department, Museum of Science and Art, Dublin.
1880. *Schemmann, Louis Carl. Hamburg. (Care of Messrs. Allen Everitt & Sons, Birmingham.)
1892. ‡*Schloss, David F. 1 Knaresborough-place, S.W.*
1842. Schofield, Joseph. Stubley Hall, Littleborough, Lancashire.
1887. ‡*Schofield, T. Thornfield, Talbot-road, Old Trafford, Manchester.*
1883. ‡Schofield, William. Alma-road, Birkdale, Southport.
1885. §Scholes, L. 14 Abington-road, Brooklands, Cheshire.
1873. *SCHUSTER, ARTHUR, Ph.D., F.R.S., F.R.A.S. (Pres. A, 1892; Council 1887–93), Professor of Physics in the Owens College. Kent House, Victoria Park, Manchester.
847. *SCLATER, PHILIP LUTLEY, M.A., Ph.D., F.R.S., F.L.S., F.G.S., F.R.G.S., Sec.Z.S. (GENERAL SECRETARY 1876–81; Pres. D, 1875; Council 1864–67, 1872–75). 3 Hanover-square, W.
883. *SCLATER, W. LUTLEY, M.A., F.Z.S. South African Museum, Cape Town.
867. ‡SCOTT, ALEXANDER. Clydesdale Bank, Dundee.
881. *SCOTT, ALEXANDER, M.A., D.Sc., F.R.S., Sec.C.S. Royal Institution, Albemarle-street, W.
878. *Scott, Arthur William, M.A., Professor of Mathematics and Natural Science in St. David's College, Lampeter.
881. ‡Scott, Miss Charlotte Angas, D.Sc. Bryn Mawr College, Pennsylvania, U.S.A.
889. *SCOTT, D. H., M.A., Ph.D., F.R.S., F.L.S. (GENERAL SECRETARY, 1900– ; Pres. K, 1896). The Old Palace, Richmond, Surrey.
885. ‡Scott, George Jamieson. Bayview House, Aberdeen.
857. *SCOTT, ROBERT H., M.A., D.Sc., F.R.S., F.R.Met.S. 6 Elm Park-gardens, S.W.

Year of Election.

1884. *Scott, Sydney C. 28 The Avenue, Gipsy Hill, S.E.
1902. §Scott, William R. The University, St. Andrew's, Scotland.
1895. ‡Scott-Elliot, Professor G. F., M.A., B.Sc., F.L.S. Ainslea, Scotstounhill, Glasgow.
1881. *Scrivener, A. P. Haglis House, Wendover.
1883. ‡Scrivener, Mrs. Haglis House, Wendover.
1895. §Scull, Miss E. M. L. The Pines, 10 Langland-gardens, Hampstead, N.W.
1890. §Searle, G. F. C., M.A. 20 Trumpington-street, Cambridge.
1859. ‡Seaton, John Love. The Park, Hull.
1880. ‡SEDGWICK, ADAM, M.A., F.R.S. (Pres. D, 1899). Trinity College, and 4 Cranmer-road, Cambridge.
1861. *SEELEY, HARRY GOVIER, F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S., Professor of Geology in King's College, London. 25 Palace Gardens-terrace, Kensington, W.
1891. ‡Selby, Arthur L., M.A., Assistant Professor of Physics in University College, Cardiff.
1893. ‡SELBY-BIGGE, L. A., M.A. Charity Commission, Whitehall, S.W.
1855. ‡Seligman, H. L. 27 St. Vincent-place, Glasgow.
1879. ‡Selim, Adolphus. 21 Mincing-lane, E.C.
1897. ‡Selous, F. C., F.R.G.S. Alpine Lodge, Worplesden, Surrey.
1884. ‡SELWYN, A. R. C., C.M.G., F.R.S., F.G.S. Ottawa, Canada.
1885. ‡Semple. Dr. A. United Service Club, Edinburgh.
1888. *SENIER, ALFRED, M.D., Ph.D., F.C.S., Professor of Chemistry in Queen's College, Galway.
1888. *Sennett, Alfred R., A.M.Inst.C.E. 304 King's-road, Chelsea, S.W.
1901. §Service, Robert. Janefield Park, Maxwelltown, Dumfries.
1870. *Sephton, Rev. J. 90 Huskisson-street, Liverpool.
1892. ‡Seton, Miss Jane. 37 Candlemaker-row, Edinburgh.
1895. *Seton-Karr, H. W. 31 Lingfield-road, Wimbledon, Surrey.
1892. §SEWARD, A. C., M.A., F.R.S., F.G.S. (Council 1901–). Westfield, Huntingdon-road, Cambridge.
1891. ‡*Seward, Edwin. 55 Newport-road, Cardiff.*
1868. ‡Sewell, Philip E. Catton, Norwich.
1899. §Seymour, Henry J., B.A., F.G.S. 16 Wellington-road, Dublin.
1891. ‡Shackell, E. W. 191 Newport-road, Cardiff.
1888. ‡*Shackles, Charles F. Hornsea, near Hull.*
1883. ‡Shadwell, John Lancelot. 30 St. Charles-square, Ladbroke Grove-road, W.
1902. §SHAFTESBURY, The Right Hon. the Earl of, D.L. Belfast Castle, Belfast.
1867. ‡Shanks, James. Dens Iron Works, Arbroath, N.B.
1881. ‡Shann, George, M.D. Petergate, York.
1878. ‡SHARP, DAVID, M.A., M.B., F.R.S., F.L.S. Museum of Zoology, Cambridge.
1896. ‡Sharp, Mrs. E. 65 Sankey-street, Warrington.
Sharp, Rev. John, B.A. Horbury, Wakefield.
1886. ‡Sharp, T. B. French Walls, Birmingham.
1883. ‡Sharples, Charles H. 7 Fishergate, Preston.
1870. ‡Shaw, Duncan. Cordova, Spain.
1896. ‡Shaw, Frank. Ellerslie, Aigburth-drive, Liverpool.
1870. ‡Shaw, John. 21 St. James's-road, Liverpool.
1891. ‡Shaw, Joseph. 1 Temple-gardens, E.C.
1889. *Shaw, Mrs. M. S., B.Sc. Sydenham Damard Rectory, Tavistock.
1883. *SHAW, W. N., M.A., D.Sc., F.R.S. (Council 1895–1900). Meteorological Office, Victoria-street, S.W.
1883. ‡Shaw, Mrs. W. N. 10 Moreton-gardens, South Kensington, S.W.

Year of
Election.

1891. ‡Sheen, Dr. Alfred. 23 Newport-road, Cardiff.
1878. ‡Shelford, William, M.Inst.C.E. 35A Great George-street, S.W.
1865. ‡Shenstone, Frederick S. Sutton Hall, Barcombe, Lewes.
1881. ‡SHENSTONE, W. A., F.R.S. Clifton College, Bristol.
1885. ‡Shepherd, Rev. Alexander. Ecclesmechen, Uphall, Edinburgh.
1890. ‡Shepherd, J. 80 Prince of Wales-mansions, Battersea, S.W.
1883. ‡Shepherd, James. Birkdale, Southport.
1900. §Sheppard, Thomas, F.G.S. The Municipal Museum, Hull.
1883. ‡Sherlock, David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Mrs. David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Rev. Edgar. Bentham Rectory, *viâ* Lancaster.
1896. §SHERRINGTON, C. S., M.D., F.R.S., Professor of Physiology in University College, Liverpool. 16 Grove-park, Liverpool.
1888. *Shickle, Rev. C. W., M.A. 5 Cavendish-crescent, Bath.
1886. ‡Shield, Arthur H. 35A Great George-street, S.W.
1892. ‡Shields, John, D.Sc., Ph.D. Dolphingston, Tranent, Scotland.
1901. §Shields, Thomas, M.A., B.Sc. Englefield Green, Surrey.
1902. *Shillington, T. Foulkes, J.P. Dromart, Antrim-road, Belfast.
1883. *Shillitoe, Buxton, F.R.C.S. 2 Frederick-place, Old Jewry, E.C.
1887. *SHIPLEY, ARTHUR E., M.A. Christ's College, Cambridge.
1889. ‡Shipley, J. A. D. Saltwell Park, Gateshead.
1885. ‡Shirras, G. F. 16 Carden-place, Aberdeen.
1883. ‡Shone, Isaac. Pentrefelin House, Wrexham.
1870. *SHOOLBRED, J. N., B.A., M.Inst.C.E. 32 Victoria-street, S.W.
1888. ‡Shoppee, C. H. 22 John-street, Bedford-row, W.C.
1897. ‡SHORE, Dr. LEWIS E. St. John's College, Cambridge.
1875. ‡SHORE, THOMAS W., F.G.S. 105 Ritherdon-road, Upper Tooting, S.W.
1882. ‡SHORE, T. W., M.D., B.Sc., Lecturer on Comparative Anatomy at St. Bartholomew's Hospital. Heathfield, Alleyn Park, Dulwich, S.E.
1901. §Short, Peter M., B.Sc. 19 Manchester-road, Southport.
1897. ‡Shortt, Professor Adam, M.A. Queen's University, Kingston, Ontario, Canada.
1889. ‡Sibley, Walter K., B.A., M.B. 8 Duke Street-mansions, Grosvenor-square, W.
1883. ‡Sibly, Miss Martha Agnes. Flook House, Taunton.
1902. §Siddons, A. W. Harrow-on-the-Hill, Middlesex.
1883. *Sidebotham, Edward John. Erlesdene, Bowdon, Cheshire.
1883. *Sidebotham, James Nasmyth. Parkfield, Altrincham, Cheshire.
1877. *Sidebotham, Joseph Watson. Merlewood, Bowdon, Cheshire.
Sidney, M. J. F. Cowpen, Newcastle-upon-Tyne.
1873. *SIEMENS, ALEXANDER, M.Inst.C.E. 7 Airlie-gardens, Campden Hill, W.
1859. ‡Sim, John. Hardgate, Aberdeen.
1871. ‡Sime, James. Craigmount House, Grange, Edinburgh.
1898. ‡Simmons, Henry. Kingsland House, Whiteladies-road, Clifton, Bristol.
1862. ‡Simms, James. 138 Fleet-street, E.C.
1874. ‡Simms, William. Upper Queen-street, Belfast.
1876. ‡Simon, Frederick. 24 Sutherland-gardens, W.
1847. ‡SIMON, Sir JOHN, K.C.B., M.D., D.C.L., F.R.S. (Council 1870–72). 40 Kensington-square, W.
1901. ‡Simpson, Rev. A., B.Sc., F.G.S. 28 Myrtle-park, Crosshill, Glasgow.
1871. *SIMPSON, ALEXANDER R., M.D., Professor of Midwifery in the University of Edinburgh. 52 Queen-street, Edinburgh.

Year of Election.

1883. ‡*Simpson, Byron R. 7 York-road, Birkdale, Southport.*
1887. ‡Simpson, F. Estacion Central, Buenos Ayres.
1859. ‡Simpson, John. Maykirk, Kincardineshire.
1863. ‡Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1901. *Simpson, J. Y., M.A., D.Sc., F.R.S.E. 52 Queen-street, Edinburgh.
1894. §Simpson, Thomas, F.R.G.S. Fennymere, Castle Bar, Ealing, W.
1883. ‡Simpson, Walter M. 7 York-road, Birkdale, Southport.
1896. *Simpson, W., F.G.S. The Gables, Halifax.
1887. ‡Sinclair, Dr. 268 Oxford-street, Manchester.
1874. ‡SINCLAIR, Right Hon. THOMAS (Local Sec. 1874). Dunedin, Belfast.
1897. ‡Sinnott, James. Bank of England-chambers, 12 Broad-street, Bristol.
1864. *Sircar, The Hon. Mahendra Lal, M.D., C.I.E. 51 Sankaritola, Calcutta.
1892. ‡Sisley, Richard, M.D. 1 Park-row, S.W.
1902. §Skeffington, J. B. Waterford.
1883. ‡Skillicorne, W. N. 9 Queen's-parade, Cheltenham.
1885. ‡Skinner, Provost. Inverurie, N.B.
1898. ‡Skinner, Sidney. Cromwell House, Trumpington, Cambridgeshire.
1889. §Slater, Matthew B., F.L.S. Malton, Yorkshire.
1884 ‡Slattery, James W. 9 Stephen's-green, Dublin.
1877. ‡Sleeman, Rev. Philip, L.Th., F.R.A.S. 65 Pembroke-road, Clifton, Bristol.
1891. §Slocombe, James. Redland House, Fitzalan, Cardiff.
1884. ‡Slooten, William Venn. Nova Scotia, Canada.
1849. ‡Sloper, George Elgar. Devizes.
1887. §Small, Evan W., M.A., B.Sc., F.G.S. The Mount, Radbourne-street, Derby.
1887. §Small, William. Lincoln-circus, The Park, Nottingham.
1889. *Smart, Professor William, LL.D. Nunholme, Dowanhill, Glasgow.
1902. §Smedley, Miss Ida. Sheepcote, Wooburn Green, near Maidenhead.
1898. ‡Smeeth, W. F., M.A., F.G.S. Mysore, India.
1876. ‡Smellie, Thomas D. 213 St. Vincent-street, Glasgow.
1877. ‡Smelt, Rev. Maurice Allen, M.A., F.R.A.S. Heath Lodge, Cheltenham.
1890. ‡Smethurst, Charles. Palace House, Harpurhey, Manchester.
1876. ‡Smieton, James. Panmure Villa, Broughty Ferry, Dundee.
1867. ‡Smieton, Thomas A. Panmure Villa, Broughty Ferry, Dundee.
1892. ‡Smith, Alexander, B.Sc., Ph.D., F.R.S.E. The University, Chicago, Illinois, U.S.A.
1897. ‡Smith, Andrew, Principal of the Veterinary College, Toronto, Canada.
1901. *Smith, Miss Annie Lorrain. 8 Essex-grove, Norwood, S.E.
1874. *Smith, Benjamin Leigh, F.R.G.S. Oxford and Cambridge Club, Pall Mall, S.W.
1887. ‡Smith, Bryce. Rye Bank, Chorlton-cum-Hardy, Manchester.
1873. ‡Smith, C. Sidney College, Cambridge.
1887. *Smith, Charles. 739 Rochdale-road, Manchester.
1889. *Smith, Professor C. Michie, B.Sc., F.R.S.E., F.R.A.S. 61 Fountainhall-road, Aberdeen.
1886. ‡Smith, Edwin. 33 Wheeley's-road, Edgbaston, Birmingham.
1886. *Smith, Mrs. Emma. Hencotes House, Hexham.
1886. ‡Smith, E. Fisher, J.P. The Priory, Dudley.
1900. §Smith, E. J. Grange House, Westgate Hill, Bradford.
1886. ‡Smith, E. O. Council House, Birmingham.
1892. ‡Smith, E. Wythe. 66 College-street, Chelsea, S.W.

Year of Election.

1897. ‡Smith, Sir Frank. 54 King-street East, Toronto, Canada.
1901. §Smith, F. B. Arkley, Bray, Maidenhead.
1866. *Smith, F. C. Bank, Nottingham.
1885. ‡Smith, Rev. G. A., M.A. 22 Sardinia-terrace, Glasgow.
1897. ‡Smith, G. Elliot, M.D. St. John's College, Cambridge.
1860. *Smith, Heywood, M.A., M.D. 18 Harley-street, Cavendish-square, W.
1870. ‡Smith, H. L. Crabwall Hall, Cheshire.
1889. *Smith, H. Llewellyn, B.A., B.Sc., F.S.S. 4 Harcourt-buildings, Inner Temple, E.C.
1888. ‡Smith, H. W. Owens College, Manchester.
1885. ‡Smith, Rev. James, B.D. Manse of Newhills, N.B.
1876. *Smith, J. Guthrie. 5 Kirklee-gardens, Kelvinside, Glasgow.
Smith, John Peter George. Sweyney Cliff, Coalport, Iron Bridge, Shropshire.
1902. §Smith, J. Lorrain, M.D., Professor of Pathology in Queen's College, Belfast. Westbourne, Windsor-avenue, Belfast.
1901. §SMITH, J. PARKER, M.P. Jordanhill, Glasgow.
1883. ‡Smith, M. Holroyd. Royal Insurance-buildings, Crossley-street, Halifax.
1885. ‡SMITH, ROBERT H., Assoc.M.Inst.C.E. Ellerslie, Sutton, Surrey.
1870. ‡Smith, Samuel. Bank of Liverpool, Liverpool.
1873. ‡Smith, Sir Swire. Lowfield, Keighley, Yorkshire.
1867. ‡Smith, Thomas. Poole Park Works, Dundee.
1859. ‡Smith, Thomas James. Hornsea Burton, East Yorkshire.
1894. §Smith, T. Walrond. Care of H. E. P. Cottrell, Esq., 92 Cavendish-road, Balham, S.W.
1884. ‡Smith, Vernon. 127 Metcalfe-street, Ottawa, Canada.
1892. ‡Smith, Walter A. 120 Princes-street, Edinburgh.
1885. **Smith, Watson. University College, Gower-street, W.C.*
1896. *Smith, Rev. W. Hodson. Newquay, Cornwall.
1852. ‡Smith, William. Eglinton Engine Works, Glasgow.
1876. ‡Smith, William. 12 Woodside-place, Glasgow.
1883. ‡SMITHELLS, ARTHUR, B.Sc., F.R.S. (Local Sec. 1890), Professor of Chemistry in the Yorkshire College, Leeds.
1883. ‡Smithson, Edward Walter. 13 Lendal, York.
1883. ‡Smithson, Mrs. 13 Lendal, York.
1882. ‡Smithson, T. Spencer. Facit, Rochdale.
1874. ‡Smoothy, Frederick. Bocking, Essex.
1857. *SMYTH, JOHN, M.A., F.C.S., F.R.M.S., M.Inst.C.E.I. Milltown, Banbridge, Ireland.
1888. *SNAPE, H. LLOYD, D.Sc., Ph.D. Balholm, Lathom-road, Southport.
1888. ‡*Snell, Albion T. Brightside, Salusbury-road, Brondesbury, N.W.*
1878. §Snell, H. Saxon. 22 Southampton-buildings, W.C.
1889. ‡Snell, W. H. Lancaster Lodge, Amersham-road, Putney, S.W.
1898. ‡Snook, Miss L. B. V. 13 Clare-road, Cotham, Bristol.
1879. *SOLLAS, W. J., M.A., D.Sc., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1900; Council 1900–), Professor of Geology in the University of Oxford. 173 Woodstock-road, Oxford.
1892. *SOMERVAIL, ALEXANDER. The Museum, Torquay.
1900. *SOMERVILLE, W. Board of Agriculture, Whitehall, S.W.
1859. *SORBY, H. CLIFTON, LL.D., F.R.S., F.G.S. (Pres. C, 1880; Council 1879–86; Local Sec. 1879). Broomfield, Sheffield.
1879. *Sorby, Thomas W. Storthfield, Ranmoor, Sheffield.
1901. §Sorley, Robert. The Firs, Partickill, Glasgow.
1888. ‡SORLEY, Professor W. R. The University, Cambridge.
1886. ‡Southall, Alfred. Carrick House, Richmond Hill-road, Birmingham.
1865. *Southall, John Tertius. Parkfields, Ross, Herefordshire.

Year of Election.

1887. §Sowerbutts, Eli, F.R.G.S. 16 St. Mary's Parsonage, Manchester.
1883. ‡Spanton, William Dunnett, F.R.C.S. Chatterley House, Hanley, Staffordshire.
1890. ‡Spark, F. R. 29 Hyde-terrace, Leeds.
1893. *Speak, John. Kirton Grange, Kirton, near Boston.
1887. ‡*Spencer, F. M. Fernhill, Knutsford.*
1884. ‡Spencer, John, M.Inst.M.E. Globe Tube Works, Wednesbury.
1889. *Spencer, John. Newbiggin House, Kenton, Newcastle-upon-Tyne.
1891. *Spencer, Richard Evans. The Old House, Llandaff.
1864. *Spicer, Henry, B.A., F.L.S., F.G.S. 14 Aberdeen-park, Highbury, N.
1894. ‡Spiers, A. H. 21 Bernard-street, Russell-square, W.C.
1864. *SPILLER, JOHN, F.C.S. 2 St. Mary's-road, Canonbury, N.
1864. *Spottiswoode, W. Hugh, F.C.S. 107 Sloane-street, S.W.
1854. *SPRAGUE, THOMAS BOND, M.A., LL.D., F.R.S.E. 29 Buckingham-terrace, Edinburgh.
1883. ‡Spratling, W. J., B.Sc., F.G.S. Maythorpe, 74 Wickham-road, Brockley, S.E.
1897. §Squire, W. Stevens, Ph.D. Clarendon House, 30 St. John's Wood Park, N.W.
1888. *Stacy, J. Sargeant. 143 Lansdown-road, Seven Kings, Essex.
1897. ‡Stafford, Joseph. Morrisburg, Ontario, Canada.
1884. ‡Stancoffe, Frederick. Dorchester-street, Montreal, Canada.
1892. ‡Stanfield, Richard, Assoc.M.Inst.C.E., F.R.S.E., Professor of Engineering in the Heriot Watt College, Edinburgh. 49 Mayfield-road, Edinburgh.
1883. *Stanford, Edward, jun., F.R.G.S. Thornbury, High-street, Bromley, Kent.
1881. *Stanley, William Ford, F.G.S. Cumberlow, South Norwood, S.E.
1883. ‡Stanley, Mrs. Cumberlow, South Norwood, S.E.
1894. *STANSFIELD, ALFRED, D.Sc. McGill University, Montreal, Canada.
1900. *Stansfield, H., B.Sc. Municipal Technical School, Blackburn.
Stapleton, M. H., M.B., M.R.I.A. 1 Mountjoy-place, Dublin.
1899. ‡STARLING, E. H., M.D., F.R.S., Professor of Physiology in University College, London. 8 Park-square West, N.W.
1876. ‡*Starling, John Henry, F.C.S. 32 Craven-street, Strand, W.C.*
1899. §Statham, William. The Redings, Totteridge, Herts.
1898. ‡Stather, J. W., F.G.S. 16 Louis-street, Hull.
Staveley, T. K. Ripon, Yorkshire.
1894. ‡Stavert, Rev. W. J., M.A. Burnsall Rectory, Skipton-in-Craven, Yorkshire.
1873. *Stead, Charles. Red Barns, Freshfield, Liverpool.
1900. *Stead, J. E. Laboratory and Assay Office, Middlesbrough.
1881. ‡Stead, W. H. Orchard-place, Blackwall, E.
1881. ‡Stead, Mrs. W. H. Orchard-place, Blackwall, E.
1884. ‡Stearns, Sergeant P. U.S. Consul-General, Montreal, Canada.
1892. *STEBBING, Rev. THOMAS R. R., M.A., F.R.S. Ephraim Lodge, The Common, Tunbridge Wells.
1896. *Stebbing, W. P. D., F.G.S. 169 Gloucester-terrace, W.
1891. ‡*Steeds, A. P. 15 St. Helen's-road, Swansea.*
1873. ‡Steinthal, G. A. 15 Hallfield-road, Bradford, Yorkshire.
1884. ‡Stephen, George. 140 Drummond-street, Montreal, Canada.
1884. ‡Stephen, Mrs. George. 140 Drummond-street, Montreal, Canada.
1884. *Stephens, W. Hudson. Low-Ville, Lewis County, New York, U.S.A.
1879. *STEPHENSON, Sir HENRY, J.P. The Glen, Sheffield.
1901. ‡Steven, William. 420 Sauchiehall-street, Glasgow.

Year of Election.

1901. ‡Steven, Mrs. W. 420 Sauchiehall-street, Glasgow.
1880. *Stevens, J. Edward, LL.B. Le Mayals, Blackpyl, R.S.O.
1900. ‡STEVENS, FREDERICK (Local Sec. 1900). Town Clerk's Office, Bradford.
1892. ‡Stevenson, D. A., B.Sc., F.R.S.E., M.Inst.C.E. 84 George-street, Edinburgh.
1902. §Stevenson, G. Albert Institute, Glasnevin, Dublin.
1863. *STEVENSON, JAMES C., M.P. Eltham Court, Eltham, Kent.
1890. *Steward, Rev. Charles J., F.R.M.S. The Cedars, Anglesea-road, Ipswich.
1885. *Stewart, Rev. Alexander, M.D., LL.D. Murtle, Aberdeen.
1864. ‡STEWART, CHARLES, M.A., F.R.S., F.L.S., Hunterian Professor of Anatomy and Conservator of the Museum, Royal College of Surgeons, Lincoln's Inn-fields, W.C.
1892. ‡Stewart, C. Hunter. 3 Carlton-terrace, Edinburgh.
1885. ‡Stewart, David. Banchory House, Aberdeen.
1886. *Stewart, Duncan. 14 Windsor-terrace West, Kelvinside, Glasgow.
1875. *Stewart, James, B.A., F.R.C.P.Ed. Dunmurry, Sneyd Park, near Clifton, Gloucestershire.
1901. *Stewart, John Joseph, M.A., B.Sc. 35 Stow Park-avenue, Newport, Monmouthshire.
1892. ‡Stewart, Samuel. Knocknairn, Bagston, Greenock.
1901. ‡Stewart, Thomas. St. George's-chambers, Cape Town.
1901. ‡Stewart, Walter, M.A., D.Sc. Gartsherrie, Coatbridge.
1901. ‡Stewart, William. Violet Grove House, St. George's-road, Glasgow.
1867. ‡Stirling, Dr. D. Perth.
1876. ‡STIRLING, WILLIAM, M.D., D.Sc., F.R.S.E., Professor of Physiology in the Owens College, Manchester.
1867. *Stirrup, Mark, F.G.S. Stamford-road, Bowdon, Cheshire.
1901. *Stobo, Thomas. Somerset House, Garelochhead, Scotland.
1865. *Stock, Joseph S. St. Mildred's, Walmer.
1890. ‡Stockdale, R. The Grammar School, Leeds.
1883. *STOCKER, W. N., M.A. Brasenose College, Oxford.
1898. ‡Stoddart, F. Wallis, F.I.C. Grafton Lodge, Sneyd Park, Bristol.
1898. *Stokes, Professor George J., M.A. Riversdale, Sunday's Well, Cork.
1887. ‡Stone, E. D., F.C.S. Rose Lea, Alderley Edge, Cheshire.
1899. *Stone, F. J. Radley College, Abingdon.
1886. ‡Stone, Sir J. Benjamin, M.P. The Grange, Erdington, Birmingham.
1886. ‡Stone, J. H. Grosvenor-road, Handsworth, Birmingham.
1874. ‡Stone, J. Harris, M.A., F.L.S., F.C.S. 3 Dr. Johnson's-buildings, Temple, E.C.
1876. ‡Stone, Octavius C., F.R.G.S. Rothbury House, Westcliff-gardens, Bournemouth.
1857. ‡STONEY, BINDON B., LL.D., F.R.S., M.Inst.C.E., M.R.I.A., Engineer of the Port of Dublin. 14 Elgin-road, Dublin.
1895. *Stoney, Miss Edith A. 30 Ledbury-road, Bayswater. W.
1878. *Stoney, G. Gerald. Oakley, Heaton-road, Newcastle-upon-Tyne.
1861. *STONEY, GEORGE JOHNSTONE, M.A., D.Sc., F.R.S., M.R.I.A. (Pres. A, 1897). 30 Ledbury-road, Bayswater, W.
1883. ‡Stopes, Mrs. 25 Denning-road, Hampstead, N.W.
1887. *Storey, H. L. Bailrigg, Lancaster.
1884. §Storrs, George H. Gorse Hall, Stalybridge.
1888. *Stothert, Percy K. The Grange, Bradford-on-Avon, Wilts.

Year of Election.
1874. ‡Stott, William. Scar Bottom, Greetland, near Halifax, Yorkshire.
1871. *STRACHEY, Lieut.-General SIR RICHARD, R.E., G.C.S.I., LL.D., F.R.S., F.R.G.S., F.L.S., F.G.S. (Pres. E, 1875; Council, 1871–75). 69 Lancaster-gate, Hyde Park, W.
1881. ‡STRAHAN, AUBREY, M.A., F.G.S. Geological Museum, Jermyn-street, S.W.
1863. ‡Straker, John. Wellington House, Durham.
1882. ‡Strange, Rev. Cresswell, M.A. Edgbaston Vicarage, Birmingham.
1898. ‡Strangeways, C. Fox. Leicester.
1881. ‡STRANGWAYS, C. FOX, F.G.S. Geological Museum, Jermyn-street, S.W.
1889. ‡Streatfeild, H. S., F.G.S. Ryhope, near Sunderland.
1879. ‡Strickland, Sir Charles W., Bart., K.C.B. Hildenley-road, Malton.
1884. ‡Stringham, Irving. The University, Berkeley, California, U.S.A.
1883. §Strong, Henry J., M.D. Colonnade House, The Steyne, Worthing.
1898. *Strong, W. M. 3 Champion-park, Denmark Hill, S.E.
1887. *Stroud, H., M.A., D.Sc., Professor of Physics in the College of Science, Newcastle-upon-Tyne.
1887. *STROUD, WILLIAM, D.Sc., Professor of Physics in the Yorkshire College, Leeds.
1878. ‡Strype, W. G. Wicklow.
1876. *Stuart, Charles Maddock, M.A. St. Dunstan's College, Catford, S.E.
1872. *Stuart, Rev. Edward A., M.A. 5 Prince's-square, W.
1892. ‡Stuart, Hon. Morton Gray, M.A., F.G.S. 2 Belford-park, Edinburgh.
1884. ‡Stuart, Dr. W. Theophilus. 183 Spadina-avenue, Toronto, Canada.
1896. ‡Stubbs, Miss. Torrisholme, Aigburth-drive, Sefton Park, Liverpool.
1885. ‡Stump, Edward C. 16 Herbert-street, Moss Side, Manchester.
1897. ‡Stupart, R. F. The Observatory, Toronto, Canada.
1879. *Styring, Robert. 64 Crescent-road, Sheffield.
1891. *Sudborough, Professor J. J., Ph.D., D.Sc. University College of Wales, Aberystwyth.
1902. §Sully, H. J. Avalon House, Priory-road, Clifton, Bristol.
1898. §Sully, T. N. Avalon House, Priory-road, Clifton, Bristol.
1884. ‡Sumner, George. 107 Stanley-street, Montreal, Canada.
1887. ‡Sumpner, W. E. 37 Pennyfields, Poplar, E.
1888. ‡Sunderland, John E. Bark House, Hatherlow, Stockport.
1883. ‡Sutcliffe, J. S., J.P. Beech House, Bacup.
1873. ‡Sutcliffe, Robert. Idle, near Leeds.
1863. ‡Sutherland, Benjamin John. Thurso House, Newcastle-upon-Tyne.
1886. ‡Sutherland, Hugh. Winnipeg, Manitoba, Canada.
1892. ‡Sutherland, James B. 10 Windsor-street, Edinburgh.
1884. ‡Sutherland, J. C. Richmond, Quebec, Canada.
1863. ‡SUTTON, FRANCIS, F.C.S. Bank Plain, Norwich.
1889. ‡Sutton, William. Esbank, Jesmond, Newcastle-upon-Tyne.
1898. §Sutton, William, M.D. 6 Camden-crescent, Dover.
1891. ‡Swainson, George, F.L.S. North Drive, St. Anne's-on-Sea, Lancashire.
1881. ‡Swales, William. Ashville, Holgate Hill, York.
1881. §SWAN, JOSEPH WILSON, M.A., F.R.S. 58 Holland-park, W.
1897. §Swanston, William, F.G.S. Mount Collyer Factory, Belfast.
1879. ‡Swanwick, Frederick. Whittington, Chesterfield.
1887. §SWINBURNE, JAMES, M.Inst.C.E. 82 Victoria-street, S.W.
1870. *Swinburne, Sir John, Bart. Capheaton Hall, Newcastle-upon-Tyne.
1887. *Swindells, Rupert, F.R.G.S. 22 Oxford-road, Birkdale, Southport.

Year of
Election.

1890. ‡SWINHOE, Colonel C., F.L.S. Avenue House, Oxford.

1891. ‡Swinnerton, R. W., Assoc.M.Inst.C.E. Bolarum, Dekkan, India.

1873. ‡Sykes, Benjamin Clifford, M.D. St. John's House, Cleckheaton.

1895. ‡Sykes, E. R. 3 Gray's Inn-place, W.C.

1902. *Sykes, Miss Ella C. Elcombs, Lyndhurst, Hampshire.

1887. *Sykes, George H., M.A., M.Inst.C.E., F.S.A. Glencoe, 64 Elmbourne-road, Tooting Common, S.W.

1902. *Sykes, Major P. Molesworth, C.M.G. Elcombs, Lyndhurst, Hampshire.

1896. *Sykes, Mark L., F.R.M.S. Chew Stoke, Somerset.

1887. *Sykes, T. H. Cringle House, Cheadle, Cheshire.

1893. ‡Symes, Rev. J. E., M.A. 70 Redcliffe-crescent, Nottingham.

1870. ‡SYMES, RICHARD GLASCOTT, M.A., F.G.S., Geological Survey of Scotland. Sheriff Court-buildings, Edinburgh.

1885. ‡SYMINGTON, JOHNSON, M.D., F.R.S.E., Professor of Anatomy in Queen's College, Belfast.

1886. ‡Symons, W. H., M.D. (Brux.), M.R.C.P., F.I.C. Guildhall, Bath.

1896. ‡Tabor, J. M. Holmwood, Harringay Park, Crouch End, N.

1898. ‡Tagart, Francis. 199 Queen's-gate, S.W.

1865. ‡Tailyour, Colonel Renny, R.E. Newmanswalls, Montrose, Forfarshire.

1894. ‡Takakusu, Jyun, B.A. 17 Worcester-terrace, Oxford.

1890. ‡TANNER, H. W. LLOYD, D.Sc., F.R.S. (Local Sec. 1891), Professor of Mathematics and Astronomy in University College, Cardiff.

1897. ‡Tanner, Professor J. H. Ithaca, New York, U.S.A.

1892. *Tansley, Arthur G., M.A., F.L.S. University College, W.C.

1883. *Tapscott, R. Lethbridge, F.R.A.S. 62 Croxteth-road, Liverpool.

1878. ‡TARPEY, HUGH. Dublin.

1861. *Tarratt, Henry W. Broadhayes, Dean Park, Bournemouth.

1857. *Tate, Alexander. Rantalard, Whitehouse, Belfast.

1893. ‡Tate, George, Ph.D. College of Chemistry, Duke-street, Liverpool.

1902. §Tate, Miss. Rantalard, Whitehouse, Belfast.

1858. *Tatham, George, J.P. Springfield Mount, Leeds.

1901. §Taylor, Benson. 22 Hayburn-crescent, Partick, Glasgow.

1884. *Taylor, Rev. Charles, D.D. St. John's Lodge, Cambridge.

1887. §Taylor, G. H. Holly House, 235 Eccles New-road, Salford.

1898. ‡Taylor, Lieut.-Colonel G. L. Le M. 6 College-lawn, Cheltenham.

1887. ‡Taylor, George Spratt. 13 Queen's-terrace, St. John's Wood, N.W.

1881. *Taylor, H. A. 69 Addison-road, Kensington, W.

1884. *TAYLOR, H. M., M.A., F.R.S. Trinity College, Cambridge.

1882. *Taylor, Herbert Owen, M.D. Oxford-street, Nottingham.

1860. *Taylor, John, M.Inst.C.E., F.G.S. 6 Queen Street-place, E.C.

1881. *Taylor, John Francis. Holly Bank House, York.

1865. ‡Taylor, Joseph. 99 Constitution-hill, Birmingham.

1876. ‡*Taylor, Robert. 70 Bath-street, Glasgow.*

1899. ‡Taylor, Robert H., M.Inst.C.E. 5 Maison Dieu-road, Dover.

1884. *Taylor, Miss S. Oak House, Shaw, near Oldham.

1900. ‡Taylor, T. H. Yorkshire College, Leeds.

1887. ‡Taylor, Tom. Grove House, Sale, Manchester.

1883. ‡Taylor, William, M.D. 21 Crockherbtown, Cardiff.

1901. §Taylor, William. 57 Sparkenhoe-street, Leicester.

1895. ‡Taylor, W. A., M.A., F.R.S.E. Royal Scottish Geographical Society, Edinburgh.

1893. ‡*Taylor, W. F. Bhootan, Whitehorse-road, Croydon, Surrey.*

1894. *Taylor, W. W., M.A. 30 Banbury-road, Oxford.

Year of Election.

1884. ‡Taylor-Whitehead, Samuel, J.P. Burton Closes, Bakewell.
1901. *Teacher, John H., M.B. 32 Huntly-gardens, Glasgow.
1858. ‡TEALE, THOMAS PRIDGIN, M.A., F.R.S. 38 Cookridge-street, Leeds.
1885. ‡TEALL, J. J. H., M.A., F.R.S., F.G.S. (Pres. C, 1893; Council 1894–1900), Director of the Geological Survey of the United Kingdom. 2 Sussex-gardens, West Dulwich, S.E.
1898. §Tebb, Robert Palmer. Enderfield, Chislehurst, Kent.
1879. ‡Temple, Lieutenant G. T., R.N., F.R.G.S. The Nash, near Worcester.
1889. ‡*Tennant, James. Saltwell, Gateshead.*
1894. ‡*Terras, J. A., B.Sc. 40 Findhorn-place, Edinburgh.*
1882. ‡Terrill, William. 42 St. George's-terrace, Swansea.
1896. *Terry, Rev. T. R., M.A., F.R.A.S. The Rectory, East Ilsley, Newbury, Berkshire.
1892. *Tesla, Nikola. 45 West 27th-street, New York, U.S.A.
1883. ‡Tetley, C. F. The Brewery, Leeds.
1883. ‡Tetley, Mrs. C. F. The Brewery, Leeds.
1882. *THANE, GEORGE DANCER, Professor of Anatomy in University College, Gower-street, W.C.
1889. ‡Thetford, The Right Rev. A. T. Lloyd, D.D., Bishop of. North Creake Rectory, Fakenham, Norfolk.
1885. ‡Thin, Dr. George. 22 Queen Anne-street, W.
1871. ‡THISELTON-DYER, Sir W. T., K.C.M.G., C.I.E., M.A., B.Sc., Ph.D., LL.D., F.R.S., F.L.S. (Pres. D, 1888; Pres. K, 1895; Council 1885–89, 1895–1900). Royal Gardens, Kew.
1870. ‡Thom, Robert Wilson. Lark Hill, Chorley, Lancashire.
1891. ‡Thomas, Alfred, M.P. Pen-y-lan, Cardiff.
1891. ‡Thomas, A. Garrod, M.D., J.P. Clytha Park, Newport, Monmouthshire.
1891. *Thomas, Miss Clara. Penurrig, Builth.
1891. ‡Thomas, Edward. 282 Bute-street, Cardiff.
1891. ‡Thomas, E. Franklin. Dan-y-Bryn, Radyr, near Cardiff.
1869. ‡Thomas, H. D. Fore-street, Exeter.
1875. ‡Thomas, Herbert. Ivor House, Redland, Bristol
1881. ‡THOMAS, J. BLOUNT. Southampton.
1869. ‡Thomas, J. Henwood, F.R.G.S. 86 Breakspears-road, Brockley, S.E.
1880. *Thomas, Joseph William, F.C.S. Overdale, Shortlands, Kent.
1899. *Thomas, Mrs. J. W. Overdale, Shortlands, Kent.
1902. §Thomas, Miss M. B. 200 Bristol-road, Birmingham.
1883. ‡Thomas, Thomas H. 45 The Walk, Cardiff.
1898. ‡Thomas, Rev. U. Bristol School Board, Guildhall, Bristol.
1883. ‡Thomas, William. Lan, Swansea.
1886. ‡Thomas, William. 109 Tettenhall-road, Wolverhampton.
1886. ‡Thomason, Yeoville. 9 Observatory-gardens, Kensington, W.
1875. ‡Thompson, Arthur. 12 St. Nicholas-street, Hereford.
1891. *Thompson, Beeby, F.C.S., F.G.S. 67 Victoria-road, Northampton.
1883. ‡Thompson, Miss C. E. Heald Bank, Bowdon, Manchester.
1891. ‡Thompson, Charles F. Penhill Close, near Cardiff.
1882. ‡Thompson, Charles O. Terre Haute, Indiana, U.S.A.
1888. *Thompson, Claude M., M.A., Professor of Chemistry in University College, Cardiff.
1885. ‡THOMPSON, D'ARCY W., B.A., C.B., Professor of Zoology in University College, Dundee.
1896. *Thompson, Edward P. Paulsmoss, Whitchurch, Salop.
1883. *Thompson, Francis. Lynton, Haling Park-road, Croydon.
1891. ‡Thompson, G. Carslake. Park-road, Penarth.

Year of Election.

1893. *Thompson, Harry J., M.Inst.C.E., Madras. Care of Messrs. Grindlay & Co., Parliament-street, S.W.
1870. ‡THOMPSON, Sir HENRY, Bart. 35 Wimpole-street, W.
1883. *Thompson, Henry G., M.D. 86 Lower Addiscombe-road, Croydon.
1891. ‡Thompson, Herbert M. Whitley Batch, Llandaff.
1891. ‡Thompson, H. Wolcott. 9 Park-place, Cardiff.
1883. *THOMPSON, ISAAC COOKE, F.L.S., F.R.M.S. (Local Sec. 1896). 53 Croxteth-road, Liverpool.
1897. ‡Thompson, J. Barclay. 37 St. Giles's, Oxford.
1891. ‡Thompson, J. Tatham, M.B. 23 Charles-street, Cardiff.
1861. *THOMPSON, JOSEPH. Riversdale, Wilmslow, Cheshire.
1876. *Thompson, Richard. Dringcote, The Mount, York.
1883. ‡Thompson, Richard. Bramley Mead, Whalley, Lancashire.
1876. ‡THOMPSON, SILVANUS PHILLIPS, B.A., D.Sc., F.R.S., F.R.A.S. (Council 1897–99), Principal and Professor of Physics in the City and Guilds of London Technical College, Finsbury, E.C.
1883. *Thompson, T. H. Redlynch House, Green-walk, Bowdon, Cheshire.
1896. *THOMPSON, W. H., M.D. 14 Hatch-street, Dublin.
1896. ‡Thompson, W. P. 6 Lord-street, Liverpool.
1867. ‡Thoms, William. Magdalen-yard-road, Dundee.
1894. ‡THOMSON, ARTHUR, M.A., M.D., Professor of Human Anatomy in the University of Oxford. Exeter College, Oxford.
1889. *Thomson, James, M.A. 22 Wentworth-place, Newcastle-upon-Tyne.
1891. ‡Thomson, John. 70A Grosvenor-street, W.
1896. ‡Thomson, John. 3 Derwent-square, Stonycroft, Liverpool.
1890. ‡THOMSON, Professor J. ARTHUR, M.A., F.R.S.E. Castleton House, Old Aberdeen.
1883. ‡THOMSON, J. J., M.A., D.Sc., F.R.S. (Pres. A, 1896; Council 1893–95), Professor of Experimental Physics in the University of Cambridge. Trinity College, Cambridge.
1871. *THOMSON, JOHN MILLAR, LL.D., F.R.S. (Council 1895–1901), Professor of Chemistry in King's College, London. 85 Addison-road, W.
1902. §Thomson, J. Stuart. Marine Biological Laboratory, Plymouth.
1901. §Thomson, Dr. J. T. Kilpatrick. 148 Norfolk-street, Glasgow.
1874. §THOMSON, WILLIAM, F.R.S.E., F.C.S. Royal Institution, Manchester.
1880. §Thomson, William J. Ghyllbank, St. Helens.
1897. ‡Thorburn, James, M.D. Toronto, Canada.
1871. ‡Thornburn, Rev. David, M.A. 1 John's-place, Leith.
1887. ‡Thornton, John. 3 Park-street, Bolton.
1867. ‡Thornton, Sir Thomas. Dundee.
1898. ‡Thornton, W. M. The Durham College of Science, Newcastle-on-Tyne.
1902. §Thornycroft, Sir John I., F.R.S., M.Inst.C.E. Eyot Villa, Chiswick Mall, W.
1883. ‡Thorowgood, Samuel. Castle-square, Brighton.
1881. ‡Thorp, Fielden. Blossom-street, York.
1881. *Thorp, Josiah. 37 Pleasant-street, New Brighton, Cheshire.
1898. §Thorp, Thomas. Moss Bank, Whitefield, Manchester.
1898. ‡Thorpe, Jocelyn Field, Ph.D. Owens College, Manchester.
1871. ‡THORPE, T. E., C.B., Ph.D., LL.D., F.R.S., F.R.S.E., V.P.C.S. (Pres. B, 1890; Council 1886–92), Principal of the Government Laboratories, Clement's Inn-passage, W.C.
1883. §Threlfall, Henry Singleton, J.P. 1 London-street, Southport.
1899. §THRELFALL, RICHARD, M.A., F.R.S. 30 George-road, Edgbaston, Birmingham.

Year of Election.

1896. §Thrift, William Edward, M.A., Professor of Natural and Experimental Philosophy in the University of Dublin. 80 Grosvenor-square, Rathmines, Dublin.

1868. ‡THUILLIER, General Sir H. E. L., R.A., C.S.I., F.R.S., F.R.G.S. Tudor House, Richmond Green, Surrey.

1889. ‡Thys, Captain Albert. 9 Rue Briderode, Brussels.

1870. ‡Tichborne, Charles R. C., LL.D., F.C.S., M.R.I.A. Apothecaries' Hall of Ireland, Dublin.

1873. *TIDDEMAN, R. H., M.A., F.G.S. 175 Banbury-road, Oxford.

1874. ‡TILDEN, WILLIAM A., D.Sc., F.R.S., Treas.C.S. (Pres. B, 1888, Council 1898–), Professor of Chemistry in the Royal College of Science, South Kensington, London. The Oaks, Northwood, Middlesex.

1883. ‡Tillyard, A. I., M.A. Fordfield, Cambridge.

1883. ‡Tillyard, Mrs. Fordfield, Cambridge.

1896. §Timmis, Thomas Sutton. Cleveley, Allerton, Liverpool.

1899. ‡Tims, H. W. Marett, M.D., F.L.S. 10 Bateman-street, Cambridge.

1902. §Tipper, Charles J. R., B.Sc. 6 Beechwood, Kendal.

1900. §Tocher, J. F., F.I.C. 5 Chapel-street, Peterhead, N.B.

1876. ‡Todd, Rev. Dr. Tudor Hall, Forest Hill, S.E.

1891. ‡Todd, Richard Rees. Portuguese Consulate, Cardiff.

1897. ‡Todhunter, James. 85 Wellesley-street, Toronto, Canada.

1889. §Toll, John M. 49 Newsham-drive, Liverpool.

1857. ‡Tombe, Rev. Canon. Glenealy, Co. Wicklow.

1888. ‡Tomkins, Rev. Henry George. Park Lodge, Weston-super-Mare.

1896. ‡*Toms, Frederick. 1 Ambleside-avenue, Streatham, S.W.*

1887. ‡Tonge, James, F.G.S. Woodbine House, West Houghton, Bolton.

1865. ‡*Tonks, Edmund, B.C.L. Packwood Grange, Knowle, Warwickshire.*

183·. *Tookey, Charles, F.C.S. Portland Hotel, Great Portland-street, W.

1875. ‡Torr, Charles Hawley. St. Alban's Tower, Mansfield-road, Sherwood, Nottingham.

1884. *Torrance, Rev. Robert, D.D. Guelph, Ontario, Canada.

1873. ‡Townend, W. H. Heaton Hall, Bradford, Yorkshire.

1875. ‡Townsend, Charles. St. Mary's, Stoke Bishop, Bristol.

1901. §Townsend, Professor John S. New College, Oxford.

1861. ‡Townsend, William. Attleborough Hall, near Nuneaton.

1877. ‡Tozer, Henry. Ashburton.

1876. *TRAIL, J. W. H., M.A., M.D., F.R.S., F.L.S., Regius Professor of Botany in the University of Aberdeen.

1883. ‡TRAILL, A., M.D., LL.D. Ballylough, Bushmills, Ireland.

1870. ‡TRAILL, WILLIAM A. Giant's Causeway Electric Tramway, Portrush, Ireland.

1868. ‡TRAQUAIR, RAMSAY H., M.D., LL.D., F.R.S., F.G.S. (Pres. D, 1900), Keeper of the Natural History Collections, Museum of Science and Art, Edinburgh.

1902. §Travers, Ernest J. Dunmurry, Co. Antrim.

1891. ‡*Trayes, Valentine. Maindell Hall, Newport Monmouthshire.*

1884. ‡Trechmann, Charles O., Ph.D., F.G.S. Hartlepool.

1868. ‡Trehane, John. Exe View Lawn, Exeter.

1891. ‡Treharne, J. Ll. 92 Newport-road, Cardiff.

Trench, F. A. Newlands House, Clondalkin, Ireland.

1887. *Trench-Gascoigne, Mrs. F. R. Lotherton Hall, Parlington, Aberford, Leeds.

1883. ‡Trendell, Edwin James, J.P. Abbey House, Abingdon, Berks.

1884. ‡Trenham, Norman W. 18 St. Alexis-street, Montreal, Canada.

1884. ‡Tribe, Paul C. M. 44 West Oneida-street, Oswego, New York, U.S.A.

1879. ‡Trickett, F. W. 12 Old Haymarket, Sheffield.

Year of Election.

1871. ‡TRIMEN, ROLAND, M.A., F.R.S., F.L.S., F.Z.S. 19 Emperor's-gate, S.W.
1860. §TRISTRAM, Rev. HENRY BAKER, D.D., LL.D., F.R.S., Canon of Durham. The College, Durham.
1902. §Tristram, Rev. J. F. 160 Moss-side, Manchester.
1884. *Trotter Alexander Pelham. 8 Richmond-terrace, Whitehall, S.W.
1885. §TROTTER, COUTTS, F.G.S., F.R.G.S. 10 Randolph-crescent, Edinburgh
1891. ‡Trounce, W. J. 67 Newport-road, Cardiff.
1887. *TROUTON, FREDERICK T., M.A., D.Sc., F.R.S., Professor of Physics in University College, W.C.
1898. §Trow, Albert Howard. Glanhafren, 50 Clive-road, Penarth.
1885. *Tubby, A. H., F.R.C.S. 25 Weymouth-street, Portland-place, W.
1847. *Tuckett, Francis Fox. Frenchay, Bristol.
1888. ‡Tuckett, William Fothergill, M.D. 18 Daniel-street, Bath.
1871. ‡Tuke, Sir J. Batty, M.D., M.P. Cupar, Fifeshire.
1883. ‡TUPPER, The Hon. Sir CHARLES, Bart., G.C.M.G., C.B. Ottawa, Canada.
1892. ‡Turnbull, Alexander R. Ormiston House, Hawick.
1855. ‡Turnbull, John. 37 West George-street, Glasgow.
1901. §Turnbull, Robert. Department of Agriculture and Technical Instruction, Dublin.
1901. ‡Turner, A. Crosbie. 65 Bath-street, Glasgow.
1893. §TURNER, DAWSON, M.B. 37 George-square, Edinburgh.
1882. ‡Turner, G. S. Pitcombe, Winchester-road, Southampton.
1883. ‡Turner, Mrs. G. S. Pitcombe, Winchester-road, Southampton.
1894. *TURNER, H. H., M.A., D.Sc., F.R.S., F.R.A.S., Professor of Astronomy in the University of Oxford. The Observatory, Oxford.
1886. *TURNER, THOMAS, A.R.S.M., F.C.S., F.I.C., Professor of Metallurgy in the University of Birmingham. 35 Wellington-road, Edgbaston, Birmingham.
1863. *TURNER, Sir WILLIAM, K.C.B., LL.D., D.C.L., F.R.S., F.R.S.E. (PRESIDENT, 1900; Pres. H, 1889, 1897), Principal of the University of Edinburgh. 6 Eton-terrace, Edinburgh.
1893. ‡TURNEY, Sir JOHN, J.P. Alexandra Park, Nottingham.
1890 *Turpin, G. S., M.A., D.Sc. High School, Nottingham.
1886. *Twigg, G. H. 56 Claremont-road, Handsworth, Birmingham.
1898. ‡Twiggs, H. W. 65 Victoria-street, Bristol.
1899. §Twisden, John R., M.A. 14 Gray's Inn-square, W.C.
1888. ‡Tyack, Llewelyn Newton. University College, Bristol.
1865. §TYLOR, EDWARD BURNETT, D.C.L., LL.D., F.R.S. (Pres. H, 1884; Council 1896–1902), Professor of Anthropology in the University of Oxford.
1883. ‡Tyrer, Thomas, F.C.S. Stirling Chemical Works, Abbey-lane, Stratford, E.
1897. ‡Tyrrell, J. B., M.A., B.Sc. Ottawa, Canada.

1884. *Underhill, G. E., M.A. Magdalen College, Oxford.
1888. ‡Underhill, H. M. 7 High-street, Oxford.
1886. ‡Underhill, Thomas, M.D. West Bromwich.
1885. §Unwin, Howard. 1 Newton-grove, Bedford Park, Chiswick, W.
1883. §Unwin, John. Eastcliffe Lodge, Southport.
1876. *UNWIN, W. C., F.R.S., M.Inst.C.E. (Pres. G, 1892; Council, 1892–99), Professor of Engineering at the Central Institution of the City and Guilds of London Institute. 7 Palace-gate Mansions, Kensington, W.
1887. ‡Upton, Francis R. Orange, New Jersey, U.S.A.
1872. ‡Upward, Alfred. 150 Holland-road, W.

Year of Election.

1876. ‡Ure, John F. 6 Claremont-terrace, Glasgow.
1866. ‡Urquhart, William W. Rosebay, Broughty Ferry, by Dundee.
1898. ‡Usher, Thomas. 3 Elmgrove-road, Cotham, Bristol.
1902. §Ussher, R. J. Cappagh House, Cappagh, Co. Waterford.
1880. ‡USSHER, W. A. E., F.G.S. 28 Jermyn-street, S.W.

1885. ‡Vachell, Charles Tanfield, M.D. 38 Charles-street, Cardiff.
1896. ‡Vacher, Francis. 7 Shrewsbury-road, Birkenhead.
1887. *Valentine, Miss Anne. The Elms, Hale, near Altrincham.
1888. ‡*Vallentin, Rupert. 18 Kimberley-road, Falmouth.*
1884. ‡Van Horne, Sir W. C., K.C.M.G. Dorchester-street West, Montreal, Canada.
1883. *Vansittart, The Hon. Mrs. A. A. Haywood House, Oaklands-road, Bromley, Kent.
1868. ‡Varley, Frederick H., F.R.A.S. Mildmay Park Works, Mildmay-avenue, Stoke Newington, N.
1865. *VARLEY, S. ALFRED. Arrow Works, Jackson-road, Holloway, N.
1870. ‡*Varley, Mrs. S. A. 5 Gayton-road, Hampstead, N.W.*
1869. ‡Varwell, P. 2 Pennsylvania Park, Exeter.
1884. ‡Vasey, Charles. 112 Cambridge-gardens, W.
1895. §Vaughan, D. T. Gwynne. Howry Hall, Llandrindod, Radnorshire.
1887. *VAUGHAN, His Eminence Cardinal. Carlisle-place, Westminster, S.W.
1875. ‡Vaughan, Miss. Burlton Hall, Shrewsbury.
1883. ‡Vaughan, William. 42 Sussex-road, Southport.
1881. §VELEY, V. H., M.A., F.R.S., F.C.S. 20 Bradmore-road, Oxford.
1873. *VERNEY, Sir EDMUND H., Bart., F.R.G.S. Claydon House, Winslow, Bucks.
1883. *Verney, Lady. Claydon House, Winslow, Bucks.
1896. *Vernon, Thomas T. Wyborne Gate, Birkdale, Southport.
1896. *Vernon, William. Tean Hurst, Tean, Stoke-upon-Trent.
1864. *VICARY, WILLIAM, F.G.S. The Priory, Colleton-crescent, Exeter.
1890. *Villamil, Lieut.-Colonel R. de, R.E. St. Mary's, Meads-road, Eastbourne.
1899. *VINCENT, SWALE, M.B. Physiological Laboratory, University College, Cardiff.
1883. *VINES, SYDNEY HOWARD, M.A., D.Sc., F.R.S., F.L.S. (Pres. K, 1900; Council, 1894–97), Professor of Botany in the University of Oxford. Headington Hill, Oxford.
1902. §Vinycomb, T. B. 43 Prospect-terrace, University-road, Belfast.
1891. ‡*Vivian, Stephen. Llantrisant.*

1886. *Wackrill, Samuel Thomas, J.P. 38 Portland-street, Leamington.
1902. §Waddell, Rev. C. H. The Vicarage, Saintfield.
1860. ‡Waddingham, John. Guiting Grange, Winchcombe, Gloucestershire.
1900. ‡Waddington, Dr. C. E. 2 Marlborough-road, Manningham, Bradford.
1888. ‡Wadworth, H. A. Breinton Court, near Hereford.
1890. §WAGER, HAROLD W. T., F.L.S. Arnold House, Bass-street, Derby.
1900. ‡Wagstaff, C. J. L., B.A. 8 Highfield-place, Manningham, Bradford.
1891. ‡Wailes, T. W. 23 Richmond-road, Cardiff.
1902. §Wainwright, Joel. Finchwood, Marple Bridge, Stockport.
1884. ‡Wait, Charles E., Professor of Chemistry in the University of Tennessee. Knoxville, Tennessee, U.S.A.
1886. ‡*Waite, J. W. The Cedars, Bestcot, Walsall.*
1870. ‡WAKE, CHARLES STANILAND. Welton, near Brough, East Yorkshire.
1884. ‡Waldstein, Professor C., M.A., Ph.D. King's College, Cambridge.

Year of Election.

1891. ‡ *Wales, H. T. Pontypridd.*
1891. ‡ Walford, Edward, M.D. Thanet House, Cathedral-road, Cardiff.
1894. ‡ WALFORD, EDWIN A., F.G.S. 21 West Bar, Banbury.
1882. *Walkden, Samuel, F.R.Met.S. Downside, Whitchurch, Tavistock.
1885. ‡ Walker, Mr. Baillie. 52 Victoria-street, Aberdeen.
1893. § Walker, Alfred O., F.L.S. Ulcombe Place, Maidstone, Kent.
1890. § Walker, A. Tannett. The Elms, Westwood, Leeds.
1901. *Walker, Archibald, M.A., F.I.C. 8 Crown-terrace, Glasgow.
1897. *WALKER, B. E., F.G.S. (Local Sec. 1897). Canadian Bank of Commerce, Toronto.
1883. ‡ Walker, Mrs. Emma. 13 Lendal, York.
1883. ‡ Walker, E. R. Pagefield Ironworks, Wigan.
1891. § Walker, Frederick W. Tannett. Carr Manor, Meanwood, Leeds.
1897. ‡ Walker, George Blake. Tankersley Grange, near Barnsley.
1894. *WALKER, G. T., M.A. Trinity College, Cambridge.
1866. ‡ Walker, H. Westwood, Newport, by Dundee.
1896. ‡ Walker, Horace. Belvidere-road, Prince's Park, Liverpool.
1890. ‡ Walker, Dr. James. 19 Springfield, Dundee.
1894. *WALKER, JAMES, M.A. 30 Norham-gardens, Oxford.
1866. *WALKER, J. FRANCIS, M.A., F.G.S., F.L.S. 45 Bootham, York.
1866. ‡ Walker, S. D. 38 Hampden-street, Nottingham.
1884. ‡ Walker, Samuel. Woodbury, Sydenham Hill, S.E.
1888. ‡ Walker, Sydney F. Bloomfield-crescent, Bath.
1887. ‡ Walker, T. A. 15 Great George-street, S.W.
1883. ‡ Walker, Thomas A. 7 Cambridge-road, Southport.
Walker, William. 47 Northumberland-street, Edinburgh.
1895. § WALKER, WILLIAM G., A.M.Inst.C.E. 47 Victoria-street, S.W.
1896. § Walker, Colonel William Hall, M.P. Gateacre, Liverpool.
1896. ‡ Walker, W. J. D. Glenhanna, Laurencetown, Co. Down, Ireland.
1883. ‡ Wall, Henry. 14 Park-road, Southport.
1863. ‡ WALLACE, ALFRED RUSSEL, D.C.L., F.R.S., F.L.S., F.R.G.S. (Pres. D, 1876; Council 1870–72). Corfe View, Parkstone, Dorset.
1897. ‡ Wallace, Chancellor. Victoria University, Toronto, Canada.
1901. § Wallace, James Sim, M.D., D.Sc. 30A Wimpole-street, W.
1892. ‡ Wallace, Robert W. 14 Frederick-street, Edinburgh.
1901. § Wallace, William, M.A., M.D. 25 Newton-place, Glasgow.
1887. *WALLER, AUGUSTUS D., M.D., F.R.S. 32 Grove End-road, N.W.
1889. *Wallis, Arnold J., M.A. 5 Belvoir-terrace, Cambridge.
1895. ‡ WALLIS, E. WHITE, F.S.S. Sanitary Institute, Parkes Museum, Margaret-street, W.
1883. ‡ Wallis, Rev. Frederick. Caius College, Cambridge.
1884. ‡ Wallis, Herbert. 239 Drummond-street, Montreal, Canada.
1886. ‡ Wallis, Whitworth, F.S.A. Chevening, Montague-road, Edgbaston, Birmingham.
1894. *WALMISLEY, A. T., M.Inst.C.E. 9 Victoria-street, Westminster, S.W.
1887. ‡ Walmsley, J. Monton Lodge, Eccles, Manchester.
1891. § Walmsley, R. M., D.Sc. Northampton Institute, Clerkenwell, E.C.
1895. ‡ WALSINGHAM, The Right Hon. Lord, LL.D., F.R.S. Merton Hall, Thetford.
1902. *Walter, Miss L. Edna. 38 Woodberry-grove, Finsbury Park, N.
1881. ‡ Walton, Thomas, M.A. Oliver's Mount School, Scarborough.
1884. ‡ Wanless, John, M.D. 88 Union-avenue, Montreal, Canada.
1887. ‡ WARD, A. W., M.A., Litt.D., Master of Peterhouse, Cambridge.
1881. § Ward, George, F.C.S. Buckingham-terrace, Headingley, Leeds.
1879. ‡ WARD, H. MARSHALL, D.Sc., F.R.S., F.L.S. (Pres. K, 1897; Council 1890–97), Professor of Botany, University of Cambridge. New Museums, Cambridge.

Year of Election.

1890. ‡Ward, Alderman John. Moor Allerton House, Leeds.
1874. §Ward, John, J.P., F.S.A. Lenoxvale, Belfast.
1887. ‡WARD, JOHN, F.G.S. 23 Stafford-street, Longton, Staffordshire.
1857. ‡Ward, John S. Prospect Hill, Lisburn, Ireland.
1880. *Ward, J. Wesney. 4 Chepstow-mansions, Chepstow-place, Bayswater, W.
1887. ‡Ward, Thomas. Brookfield House, Northwich.
1882. ‡Ward, William. Cleveland Cottage, Hill-lane, Southampton.
1867. ‡Warden, Alexander J. 23 Panmure-street, Dundee.
1901. §Wardlaw, Alexander. 21 Hamilton-drive, Hillhead, Glasgow.
1858. ‡Wardle, Sir Thomas, F.G.S. St. Edward-street, Leek, Staffordshire.
1884. ‡Wardwell, George J. 31 Grove-street, Rutland, Vermont, U.S.A.
1887. *Waring, Richard S. Standard Underground Cable Co., 16th-street, Pittsburg, Pennsylvania, U.S.A.
1878. ‡WARINGTON, ROBERT, F.R.S., F.C.S. High Bank, Harpenden, St. Albans, Herts.
1882. ‡ *Warner, F. I., F.L.S. 20 Hyde Street, Winchester.*
1884. *Warner, James D. 199 Baltic-street, Brooklyn, U.S.A.
1896. ‡Warrand, Major-General, R.E. Westhorpe, Southwell, Middlesex.
1887. ‡WARREN, Lieut.-General Sir CHARLES, R.E., K.C.B., G.C.M.G., F.R.S., F.R.G.S. (Pres. E, 1887). Athenæum Club, S.W.
1898. ‡ *Warrington, Arthur W. University College, Aberystwith.*
1893. ‡Warwick, W. D. Balderton House, Newark-on-Trent.
1875. *WATERHOUSE, Major-General J. Oak Lodge, Court-road, Eltham, Kent.
1870. ‡Waters, A. T. H., M.D. 60 Bedford-street, Liverpool.
1900. §Waterston, David, M.D. 16 Merchiston-terrace, Edinburgh.
1892. ‡Waterston, James H. 37 Lutton-place, Edinburgh.
1875. †Watherston, Rev. Alexander Law, M.A., F.R.A.S. The Grammar School, Hinckley, Leicestershire.
1884. ‡Watson, A. G., D.C.L. Uplands, Wadhurst, Sussex.
1901. *Watson, Arnold Thomas, F.L.S. Southwold, Tapton Crescent-road, Sheffield.
1886. *Watson, C. J. Alton Cottage, Botteville-road, Acock's Green, Birmingham.
1883. ‡Watson, C. Knight, M.A. 49 Bedford-square, W.C.
1892. §Watson, G., Assoc.M.Inst.C.E. 21 Springfield-mount, Leeds.
1885. ‡Watson, Deputy Surgeon-General G. A. Hendre, Overton Park, Cheltenham.
1884. ‡Watson, John. Queen's University, Kingston, Ontario, Canada.
1889. ‡Watson, John, F.I.C. P.O. Box 317, Johannesburg, South Africa.
1863. ‡Watson, Joseph. Bensham-grove, Gateshead.
1863. ‡Watson, R. Spence, LL.D., F.R.G.S. Bensham-grove, Gateshead.
1867. ‡Watson, Thomas Donald. 16 St. Mary's-road, Bayswater, W.
1894. *WATSON, Professor W., B.Sc., F.R.S. 7 Upper Cheyne-row, S.W.
1892. §Watson, William, M.D. Waverley House, Slateford, Midlothian.
1879. *WATSON, WILLIAM HENRY, F.C.S., F.G.S. Steelfield Hall, Gosforth, Cumberland.
1882. ‡Watt, Alexander. 29 Grange Mount, Claughton, Birkenhead.
1884. ‡Watt, D. A. P. 284 Upper Stanley-street, Montreal, Canada.
1901. §Watt, Henry Anderson. Ardenslate House, Kirn, Argyllshire.
1869. ‡ *Watt, Robert B. E. Ashley-avenue, Belfast.*
1888. ‡WATTS, B. H. (Local Sec. 1888). 10 Rivers-street, Bath.
1875. *WATTS, JOHN, B.A., D.Sc. Merton College, Oxford.
1884. *Watts, Rev. Canon Robert R. Stourpaine Vicarage, Blandford.

Year of Election.

1870. §Watts, William, F.G.S. Little Don Waterworks, Langsett, near Penistone.
1896. ‡Watts, W. H. Elm Hall, Wavertree, Liverpool.
1873. ***Watts, W. Marshall**, D.Sc. Giggleswick Grammar School, and Carrholme, Stackhouse, near Settle.
1883. ***Watts, W. W.**, M.A., Sec.G.S. (Council 1902–), Assistant Professor of Geology in the University, Birmingham. Holm Wood, Bracebridge-road, Sutton Coldfield.
1891. ‡Waugh, James. Higher Grade School, 110 Newport-road, Cardiff.
1869. ‡Way, Samuel James. Adelaide, South Australia.
1883. ‡Webb, George. 5 Tenterden-street, Bury, Lancashire.
1871. ‡Webb, Richard M. 72 Grand-parade, Brighton.
1886. §**Webber**, Major-General C. E., C.B., M.Inst.C.E. 17 Egerton-gardens, S.W.
1891. §Webber, Thomas. The Laurels, 83 Newport-road, Roath, Cardiff.
1859. ‡Webster, John. Edgehill, Aberdeen.
1884. *Wedekind, Dr. Ludwig, Professor of Mathematics at Karlsruhe. Jahnstrasse 5, Karlsruhe.
1889. ‡Weeks, John G Bedlington.
1890. ***Weiss, F. Ernest**, B.Sc., F.L.S., Professor of Botany in Owens College, Manchester.
1886. ‡Weiss, Henry. Westbourne-road, Birmingham.
1865. ‡Welch, Christopher, M.A. United University Club, Pall Mall East, S.W.
1902. §Welch, R. J. 49 Lonsdale-street, Belfast.
1894. ‡Weld, Miss. Conal More, Norham-gardens, Oxford.
1876. ***Weldon**, Professor W. F. R., M.A., F.R.S., F.L.S. (Pres. D, 1898). The Museum, Oxford.
1880. *Weldon, Mrs. Merton Lea, Oxford.
1897. ‡Welford, A. B., M.B. Woodstock, Ontario, Canada.
1881. §Wellcome, Henry S. Snow Hill-buildings, E.C.
1879. §**Wells, Charles A.**, A.I.E.E. 219 High-street, Lewes.
1881. §Wells, Rev. Edward, M.A. West Dean Rectory, Salisbury.
1894. ‡Wells, J. G. Selwood House, Shobnall-street, Burton-on-Trent.
1883. ‡Welsh, Miss. Girton College, Cambridge.
1881. *Wenlock, The Right Hon. Lord. Escrick Park, Yorkshire.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. Roslyn, Walland's Park, Lewes.
1886. *Wertheimer, Julius, B.A., B.Sc., F.C.S., Principal of and Professor of Chemistry in the Merchant Venturers' Technical College, Bristol.
1865. ‡Wesley, William Henry. Royal Astronomical Society, Burlington House, W.
1853. ‡West, Alfred. Holderness-road, Hull.
1898. ‡West, Charles D. Imperial University, Tokyo, Japan.
1853. †West, Leonard. Summergangs Cottage, Hull.
1900. §West, William, F.L.S. 26 Woodville-terrace, Horton-lane, Bradford.
1897. ‡Western, Alfred E. 36 Lancaster-gate, W.
1882. *Westlake, Ernest, F.G.S. Fordingbridge, Salisbury.
1882. ‡Westlake, Richard. Portswood, Southampton.
1882. ‡**Wethered, Edward B.**, F.G.S. 4 St. Margaret's-terrace, Cheltenham.
1900. §Wethey, E. R., M.A., F.R.G.S. 5 Cunliffe-villas, Manningham, Bradford.
1885. ***Wharton**, Admiral Sir W. J. L., K.C.B., R.N., F.R.S., F.R.A.S., F.R.G.S. (Pres. E, 1894; Council 1890–91), Hydrographer to the Admiralty. Florys, Prince's-road, Wimbledon Park, Surrey.

Year of Election.

1884. ‡Wheeler, Claude L., M.D. 251 West 52nd-street, New York City, U.S.A.

1878. *Wheeler, W. H., M.Inst.C.E. Wyncote, Boston, Lincolnshire.

1888. §Whelen, John Leman. 18 Frognal, Hampstead, N.W.

1883. ‡*Whelpton, Miss K. Newnham College, Cambridge.*

1893. *WHETHAM, W. C. D., M.A., F.R.S. Trinity College, Cambridge.

1888. *Whidborne, Miss Alice Maria. Charanté, Torquay.

1888. *Whidborne, Miss Constance Mary. Charanté, Torquay.

1879. *WHIDBORNE, Rev. GEORGE FERRIS, M.A., F.G.S. The Priory, Westbury-on-Trym, near Bristol.

1898. *Whipple, Robert S. Scientific Instrument Company, Cambridge.

1874. ‡*Whitaker, Henry, M.D. Fortwilliam-terrace, Belfast.*

1883. *Whitaker, T. Walton House, Burley-in-Wharfedale.

1859. *WHITAKER, WILLIAM, B.A., F.R.S., F.G.S. (Pres. C, 1895; Council 1890-96.) 3 Campden-road, Croydon.

1884. ‡Whitcher, Arthur Henry. Dominion Lands Office, Winnipeg, Canada.

1886. ‡Whitcombe, E. B. Borough Asylum, Winson Green, Birmingham

1897. ‡Whitcombe, George. The Wotton Elms, Wotton, Gloucester.

1886. ‡*White, Alderman, J.P. Sir Harry's-road, Edgbaston, Birmingham.*

1876. ‡White, Angus. Easdale, Argyllshire.

1886. ‡White, A. Silva. 47 Clanricarde-gardens, W.

1898. ‡White, George. Clare-street House, Bristol.

1882. ‡White, Rev. George Cecil, M.A. Nutshalling Rectory, Southampton.

1885. *White, J. Martin. Balruddery, Dundee.

1873. ‡White, John. Medina Docks, Cowes, Isle of Wight.

1883. ‡White, John Reed. Rossall School, near Fleetwood.

1865. ‡White, Joseph. 6 Southwell-gardens, S.W.

1895. ‡White, Philip J., M.B., Professor of Zoology in University College, Bangor, North Wales.

1884. ‡White, R. 'Gazette' Office, Montreal, Canada.

1898. ‡White, Samuel. Clare-street House, Bristol.

1859. ‡White, Thomas Henry. Tandragee, Ireland.

1877. *White, William. 20 Hillersdon-avenue, Church-road, Barnes, S.W.

1886. **White, William. The Ruskin Museum, Sheffield.*

1897. *WHITE, Sir W. H., K.C.B., F.R.S. (Pres. G, 1899; Council 1897-1900). 30 Roland-gardens, S.W.

1883. ‡Whitehead, P. J. 6 Cross-street, Southport.

1893. §Whiteley, R. Lloyd, F.C.S., F.I.C. 5 Bagnall-street, West Bromwich.

1881. ‡Whitfield, John, F.C.S. 113 Westborough, Scarborough.

1900. ‡Whitley, E. N. Heath Royde, Halifax.

1891. §Whitmell, Charles T., M.A., B.Sc. Invermay, Headingley, Leeds.

1896. §Whitney, Colonel C. A. The Grange, Fulwood Park, Liverpool.

1897. ‡WHITTAKER, E. T., M.A. Trinity College, Cambridge.

1901. §Whitton, James. City Chambers, Glasgow.

1857. *WHITTY, Rev. JOHN IRWINE, M.A., D.C.L., LL.D. Alpha Villa, Southwood, Ramsgate.

1887. ‡Whitwell, William. Overdene, Saltburn-by-the-Sea.

1874. *Whitwill, Mark. 1 Berkeley-square, Clifton, Bristol.

1883. ‡Whitworth, James. 36 Lethbridge-road, Southport.

1870. ‡Whitworth, Rev. W. Allen, M.A. 7 Margaret-street, W.

1892. §Whyte, Peter, M.Inst.C.E. 4 Magdala-crescent, Edinburgh.

1897. ‡Wickett, M., Ph.D. 339 Berkeley-street, Toronto, Canada.

1888. ‡Wickham, Rev. F. D. C. Horsington Rectory, Bath.

1865. ‡Wiggin, Sir H., Bart. Metchley Grange, Harborne, Birmingham.

Year of
Election.

1886. ‡*Wiggin, Henry A. The Lea, Harborne, Birmingham.*
1896. ‡Wigglesworth, J. County Asylum, Rainhill, Liverpool.
1878. ‡Wigham, John R. Albany House, Monkstown, Dublin.
1889. *WILBERFORCE, Professor L. R., M.A. University College, Liverpool.
1887. ‡Wild, George. Bardsley Colliery, Ashton-under-Lyne.
1887. *WILDE, HENRY, D.Sc., F.R.S. The Hurst, Alderley Edge, Cheshire.
1896. ‡Wildermann, Meyer. Royal Institution, Albemarle-street, W.
1900. §Wilkinson, J. B. Dudley Hill, Bradford.
1892. ‡Wilkinson, Rev. J. Frome., M.A. Barley Rectory, Royston, Herts.
1886. *Wilkinson, J. H. Elmhurst Hall, Lichfield.
1887. *Wilkinson, Thomas Read. Vale Bank, Knutsford, Cheshire.
1872. ‡Wilkinson, William. 168 North-street, Brighton.
1890. ‡*Willans, J. W. Kirkstall, Leeds.*
1872. ‡WILLETT, HENRY (Local Sec. 1872). Arnold House, Brighton.
1894. ‡Willey, Arthur, D.Sc., F.R.S. New Museums, Cambridge.
1891. ‡Williams, Arthur J., M.P. Coedymwstwr, near Bridgend.
1861. *Williams, Charles Theodore, M.A., M.B. 2 Upper Brook-street, Grosvenor-square, W.
1887. ‡Williams, Sir E. Leader, M.Inst.C.E. The Oaks, Altrincham.
1883. *Williams, Edward Starbuck. Ty-ar-y-graig, Swansea.
1861. *Williams, Harry Samuel, M.A., F.R.A.S. 6 Heathfield, Swansea.
1875. *Williams, Rev. Herbert Addams. Llangibby Rectory, near Newport, Monmouthshire.
1883. ‡Williams, Rev. H. Alban, M.A. Christ Church, Oxford.
1888. ‡Williams, James. Bladud Villa, Entry Hill, Bath.
1891. §Williams, J. A. B., M.Inst.C.E. Lingfield Grange, Branksome Park, Bournemouth.
1883. *Williams, Mrs. J. Davies. 3 Lord-street West, Southport.
1887. ‡Williams, J. Francis, Ph.D. Salem, New York, U.S.A.
1888. *Williams, Miss Katharine T. Llandaff House, Pembroke-vale, Clifton, Bristol.
1875. *Williams, M. B. Killay House, Killay, R.S.O.
1901. *Williams, Miss M. F. S. 6 Sloane-gardens, S.W.
1891. ‡Williams, Morgan. 5 Park-place, Cardiff.
1886. ‡Williams, Richard, J.P. Brunswick House, Wednesbury.
1883. ‡Williams, R. Price. 28 Compayne-gardens, West Hampstead, N.W.
1883. ‡Williams, T. H. 21 Strand-street, Liverpool.
1877. *WILLIAMS, W. CARLETON, F.C.S. University College, Sheffield.
1850. *WILLIAMSON, ALEXANDER W., Ph.D., LL.D., D.C.L., F.R.S. (PRESIDENT, 1873; TREASURER, 1874–91; Pres. B, 1863, 1881; Council 1861–72). High Pitfold, Haslemere.
1857. ‡WILLIAMSON, BENJAMIN, M.A., D.C.L., F.R.S. Trinity College, Dublin.
1876. ‡Williamson, Rev. F. J. Ballantrae, Girvan, N.B.
1895. ‡WILLINK, W. (Local Sec. 1896). 14 Castle-street, Liverpool.
1895. ‡Willis, John C., M.A., Director of the Royal Botanical Gardens, Ceylon.
1896. ‡WILLISON, J. S. (Local Sec. 1897). Toronto, Canada.
1882. ‡Willmore, Charles. Queenwood College, near Stockbridge, Hants.
1859. *Wills, The Hon. Sir Alfred. Chelsea Lodge, Tite-street, S.W.
1886. ‡Wills, A. W. Wylde Green, Erdington, Birmingham.
1898. ‡Wills, H. H. Barley Wood, Wrington, R.S.O., Somerset.
1899. §Willson, George. 12 St. Leonard's-terrace, Streatham, S.W.
1899. §Willson, Mrs. George. 12 St. Leonard's-terrace, Streatham, S.W.
1886. ‡Wilson, Alexander B. Holywood, Belfast.

Year of Election.

1901. §Wilson, A. Belvoir Park, Newtownbreda, Co. Down.
1878. ‡Wilson, Professor Alexander S., M.A., B.Sc. Free Church Manse, North Queensferry.
1876. ‡Wilson, Dr. Andrew. 118 Gilmore-place, Edinburgh.
1894. *Wilson, Charles J., F.I.C., F.C.S. 14 Old Queen-street, Westminster, S.W.
1874. ‡WILSON, Major-General Sir C. W., R.E., K.C.B., K.C.M.G., D.C.L., F.R.S., F.R.G.S. (Pres E, 1874, 1888). The Athenæum Club, S.W.
1876. ‡Wilson, David. 124 Bothwell-street, Glasgow.
1900. *Wilson, Duncan R. Menethorpe, Malton.
1890. ‡Wilson, Edmund. Denison Hall, Leeds.
1863. ‡Wilson, Frederic R. Alnwick, Northumberland.
1847. *Wilson, Frederick. 99 Albany-street, N.W.
1874. *Wilson, George Orr. 20 Berkeley-street, W.
1863. ‡Wilson, George W. Heron Hill, Hawick, N.B.
1895. ‡Wilson, Dr. Gregg. The University, Edinburgh.
1901. §Wilson, Harold A. Trinity College, Cambridge.
1902. *Wilson, Harry, F.I.C. 146 High-street, Southampton.
1883. *Wilson, Henry, M.A. Farnborough Lodge, Farnborough, R.S.O., Kent.
1879. ‡Wilson, Henry J. 255 Pitsmoor-road, Sheffield.
1885. ‡Wilson, J. Dove, LL.D. 17 Rubislaw-terrace, Aberdeen.
1890. ‡Wilson, J. Mitchell, M.D. 51 Hall-gate, Doncaster.
1865. ‡WILSON, Ven. Archdeacon JAMES M., M.A., F.G.S. The Vicarage, Rochdale.
1884. ‡Wilson, James S. Grant. Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1879. ‡Wilson, John Wycliffe. Eastbourne, East Bank-road, Sheffield.
1901. *Wilson, Joseph. Columba Villa, Oban, N.B.
1901. §Wilson, Mrs. Mary R., M.D. Ithaca, New York, U.S.A.
1876. ‡Wilson, R. W. R. St. Stephen's Club, Westminster, S.W.
1847. *Wilson, Rev. Sumner. Preston Candover Vicarage, Basingstoke.
1883. ‡Wilson, T. Rivers Lodge, Harpenden, Hertfordshire.
1892. §Wilson, T. Stacey, M.D. Wyddrington, Edgbaston, Birmingham.
1887. §Wilson, W., jun. Hillocks of Terpersie, by Alford, Aberdeenshire.
1871. *WILSON, WILLIAM E., D.Sc., F.R.S. Daramona House, Streete, Rathowen, Ireland.
1877. ‡Windeatt, T. W. Dart View, Totnes.
1886. ‡WINDLE, BERTRAM C. A., M.A., M.D., D.Sc., F.R.S., Professor of Anatomy, The University, Birmingham.
1863. *WINWOOD, Rev. H. H., M.A., F.G.S. (Local Sec. 1864). 11 Cavendish-crescent, Bath.
1902. *Withers, H. L., M.A., Professor of Education in Owens College, Manchester.
1888. ‡WODEHOUSE, Right Hon. E. R., M.P. 56 Chester-square, S.W.
1875. ‡WOLFE-BARRY, Sir JOHN, K.C.B., F.R.S., M.Inst.C.E. (Pres. G, 1898; Council, 1899–). 21 Delahay-street, Westminster, S.W.
1883. ‡Wolfenden, Samuel. Cowley Hill, St. Helens, Lancashire.
1898. ‡Wollaston, G. H. Clifton College, Bristol.
1884. ‡Womack, Frederick, M.A., B.Sc., Lecturer on Physics and Applied Mathematics at St. Bartholomew's Hospital. Bedford College, Baker-street, W.
1883. ‡Wood, Mrs. A. J. 5 Cambridge-gardens, Richmond, Surrey.
1863. *Wood, Collingwood L. Freeland, Forgandenny, N.B.
1883. ‡Wood, Miss Emily F. Egerton Lodge, near Bolton, Lancashire.
1901. *Wood, Miss Ethel M. 3 Shorncliffe-road, Folkestone.

Year of Election.

1875. *Wood, George William Rayner. Singleton, Manchester.
1878. ‡WOOD, Sir H. TRUEMAN, M.A. Society of Arts, John-street, Adelphi, W.C.; and 16 Leinster-square, Bayswater, W.
1883. *Wood, J. H. 21 Westbourne-road, Birkdale.
1893. ‡Wood, Joseph T. 29 Muster's-road, West Bridgeford, Nottinghamshire.
1864. ‡Wood, Richard, M.D. Driffield, Yorkshire.
1871. ‡Wood, Provost T. Baileyfield, Portobello, Edinburgh.
1899. *Wood, W. Hoffman. Ben Rhydding, Yorkshire.
1901. *Wood, William James. 266 George-street, Glasgow.
1872. ‡Wood, William Robert. Carlisle House, Brighton.
1845. *Wood, Rev. William Spicer, M.A., D.D. Waldington, Combe Park, Bath.
1884. ‡Woodbury, C. J. H. 31 Milk-street, Boston, U.S.A.
1883. ‡Woodcock, Herbert S. The Elms, Wigan.
1884. ‡Woodd, Arthur B. Woodlands, Hampstead, N.W.
1896. §WOODHEAD, Professor G. SIMS, M.D. Pathological Laboratory, Cambridge.
1888. *Woodiwiss, Mrs. Alfred. Weston Manor, Birkdale, Lancashire.
1872. *WOODS, EDWARD, M.Inst.C.E. (Pres. G, 1877). 8 Victoria-street, Westminster, S.W.
WOODS, SAMUEL. 1 Drapers'-gardens, Throgmorton-street, E.C.
1887. *WOODWARD, ARTHUR SMITH, LL.D., F.R.S., F.L.S., F.G.S., Keeper of the Department of Geology, British Museum (Natural History), Cromwell-road, S.W.
1869. *WOODWARD, C. J., B.Sc., F.G.S. Field View Cottage, Metchley-lane, Harborne, Birmingham.
1886. ‡Woodward, Harry Page, F.G.S. 129 Beaufort-street, S.W.
1866. ‡WOODWARD, HENRY, LL.D., F.R.S., F.G.S. (Pres. C, 1887; Council, 1887–94). 129 Beaufort-street, Chelsea, S.W.
1870. ‡WOODWARD, HORACE B., F.R.S., F.G.S. Geological Survey Office, Jermyn-street, S.W.
1894. *Woodward, John Harold. 13 Queen Anne's-gate, Westminster, S.W.
1884. *Woolcock, Henry. Rickerby House, St. Bees.
1890. *Woollcombe, Robert Lloyd, M.A., LL.D., F.I.Inst., F.S.S., M.R.I.A., F.R.S.A. (Ireland). 14 Waterloo-road, Dublin.
1877. ‡ *Woollcombe, Surgeon-Major Robert W.* 14 *Acre-place, Stoke, Devonport.*
1883. *Woolley, George Stephen. Victoria Bridge, Manchester.
1856. ‡Woolley, Thomas Smith. South Collingham, Newark.
1878. ‡Wormell, Richard, M.A., D.Sc. Roydon, near Ware, Hertfordshire.
1863. *Worsley, Philip J. Rodney Lodge, Clifton, Bristol.
1901. §Worth, J. T. Oakenrod Mount, Rochdale.
1855. *Worthington, Rev. Alfred William, B.A. Old Swinford, Stourbridge.
1856. ‡ *Worthy, George S.* 2 *Arlington-terrace, Mornington-crescent, Hampstead-road, N.W.*
1884. ‡Wragge, Edmund. 109 Wellesley-street, Toronto, Canada.
1896. ‡Wrench, Edward M., F.R.C.S. Park Lodge, Bastow.
1879. ‡Wrentmore, Francis. 34 Holland Villas-road, Kensington, S.W.
1883. *Wright, Rev. Arthur, M.A. Queen's College, Cambridge.
1883. *Wright, Rev. Benjamin, M.A. Sandon Rectory, Chelmsford.
1890. ‡Wright, Dr. C. J. Virginia-road, Leeds.
1857. ‡WRIGHT, E. PERCEVAL, M.A., M.D., F.L.S., M.R.I.A., Professor of Botany and Director of the Museum, Dublin University. 5 Trinity College, Dublin.

Year of Election.

1886. ‡Wright, Frederick William. 4 Full-street, Derby.
1884. ‡Wright, Harrison. Wilkes' Barré, Pennsylvania, U.S.A.
1876. ‡Wright, James. 114 John-street, Glasgow.
1902. §Wright, John. The White House, Burns-street, Nottingham.
1874. ‡Wright, Joseph, F.G.S. 4 Alfred-place, Belfast.
1865. ‡Wright, J. S. 168 Brearley-street West, Birmingham.
1884. ‡WRIGHT, Professor R. RAMSAY, M.A., B.Sc. University College, Toronto, Canada.
1876. ‡Wright, William. 31 Queen Mary-avenue, Glasgow.
1871. ‡WRIGHTSON, Sir THOMAS, Bart., M.P., M.Inst.C.E., F.G.S. Neasham Hall, Darlington.
1898. ‡Wrong, Professor George M. The University, Toronto, Canada.
1902. §Wyatt, G. H. 1 Maurice-road, St. Andrew's Park, Bristol.
1897. ‡Wyld, Frederick. 127 St. George-street, Toronto, Canada.
1901. §Wylie, Alexander. Kirkfield, Johnstone, N.B.
1902. §Wylie, John. 2 Mafeking-villas, Whitehouse, Belfast.
1885. ‡Wyness, James D., M.D. 349 Union-street, Aberdeen.
1871. ‡Wynn, Mrs. Williams. Plas-yn-Cefn, St. Asaph.
1862. ‡WYNNE, ARTHUR BEEVOR, F.G.S. Geological Survey Office, 14 Hume-street, Dublin.
1899. ‡WYNNE, W. P., D.Sc., F.R.S., Professor of Chemistry to the Pharmaceutical Society of Great Britain. 10 Selwood-terrace, South Kensington, S.W.

1875. ‡Yabbicom, Thomas Henry. 23 Oakfield-road, Clifton, Bristol.
1901. §Yapp, R. H. Caius College, Cambridge.
*Yarborough, George Cook. Camp's Mount, Doncaster.
1894. *Yarrow, A. F. Poplar, E.
1896. ‡Yates, Rev. S. A. Thompson. 43 Phillimore-gardens, S.W.
1884. ‡Yee, Fung. Care of R. E. C. Fittock, Esq., Shanghai, China.
1877. ‡Yonge, Rev. Duke. Puslinch, Yealmpton, Devon.
1884. ‡York, Frederick. 87 Lancaster-road, Notting Hill, W.
1891. §Young, Alfred C., F.C.S. 53 Algiers-road, Ladywell, S.E.
1886. *YOUNG, A. H., M.B., F.R.C.S. (Local Sec. 1887), Professor of Anatomy in Owens College, Manchester.
1884. ‡Young, Sir Frederick, K.C.M.G. 5 Queensberry-place, S.W.
1894. *Young, George, Ph.D. University College, Sheffield.
1884. ‡Young, Professor George Paxton. 121 Bloor-street, Toronto, Canada.
1876. *Young, John. 2 Montague-terrace, Kelvinside, Glasgow.
1896. ‡*Young, J. Denholm.* 88 *Canning-street, Liverpool.*
1885. ‡Young, R. Bruce. 8 Crown-gardens, Dowanhill, Glasgow.
1901. §Young, Robert M., B.A. Rathvarna, Belfast.
1883. *YOUNG, SYDNEY, D.Sc., F.R.S., Professor of Chemistry in University College, Bristol. 6 Windsor-terrace, Clifton, Bristol.
1887. ‡Young, Sydney. 29 Mark-lane, E.C.
1890. ‡Young, T. Graham, F.R.S.E. Westfield, West Calder, Scotland.
1901. ‡Young, William Andrew. Milburn House, Renfrew.

1886. ‡Zair, George. Arden Grange, Solihull, Birmingham.
1886. ‡Zair, John. Merle Lodge, Moseley, Birmingham.

CORRESPONDING MEMBERS.

Year of Election.

1887. Professor Cleveland Abbe. Weather Bureau, Department of Agriculture, Washington, D.C., U.S.A.
1892. Professor Svante Arrhenius. The University, Stockholm. (Bergegatan 18).
1881. Professor G. F. Barker. 3909, Locust-street, Philadelphia, U.S.A.
1897. Professor Carl Barus. Brown University, Providence, R.I., U.S.A.
1894. Professor F. Beilstein. 8th Line, No. 17, St. Petersburg.
1894. Professor E. van Beneden. 50 quai des Pêcheurs, Liége, Belgium.
1887. Professor A. Bernthsen, Ph.D. Mannheim, L 11, 4, Germany.
1892. Professor M. Bertrand. 75 rue de Vaugirard, Paris.
1894. Deputy Surgeon-General J. S. Billings. 40 Lafayette Place, New York, U.S.A.
1893. Professor Christian Bohr. Bredgade 62, Copenhagen, Denmark.
1880. Professor Ludwig Boltzmann. XVIII. Haizingergasse 26, Vienna.
1887. Professor Lewis Boss. Dudley Observatory, Albany, New York, U.S.A.
1884. Professor H. P. Bowditch, M.D. Harvard Medical School, Boston, Massachusetts, U.S.A.
1890. Professor Dr. L. Brentano. Friedrichstrasse 11, München.
1893. Professor Dr. W. C. Brögger. Universitets Mineralogske Institute, Kristiania, Norway.
1887. Professor J. W. Brühl. Heidelberg.
1884. Professor George J. Brush. Yale University, New Haven, Conn., U.S.A.
1894. Professor D. H. Campbell. Stanford University, Palo Alto, California, U.S.A.
1897. M. C. de Candolle. 3 Cour de St. Pierre, Geneva, Switzerland.
1887. Professor G. Capellini. 65 Via Zamboni, Bologna, Italy.
1887. Hofrath Dr. H. Caro. C. 8, No. 9, Mannheim.
1894. Emile Cartailhac. 5 Rue de la Chaîne, Toulouse, France.
1861. Professor Dr. J. Victor Carus. Universitätstrasse 15, Leipzig.
1901. Professor T. C. Chamberlin. Chicago, U.S.A.
1894. Dr. A. Chauveau. Rue Cuvier 7, Paris.
1887. F. W. Clarke. United States Geological Survey, Washington, U.S.A.
1873. Professor Guido Cora. Via Goito 2, Rome.
1876. Professor Luigi Cremona. 5 Piazza S. Pietro in Vincoli, Rome.
1889. W. H. Dall. United States Geological Survey, Washington, D.C., U.S.A.
1901. Dr. Yves Delage. Paris.
1872. Professor G. Dewalque. 17 rue de la Paix, Liége, Belgium.
1870. Dr. Anton Dohrn, D.C.L. Naples.

Year of Election.

1890. Professor V. Dwelshauvers-Dery. 4 Quai Marcellis, Liége, Belgium.
1876. Professor Alberto Eccher. Florence.
1894. Professor Dr. W. Einthoven. Leiden, Netherlands.
1892. Professor F. Elfving. Helsingfors, Finland.
1901. Professor H. Elster, Wolfenbüttel, Germany.
1894. Professor T. W. W. Engelmann, D.C.L. Neue Wilhelmstrasse 15, Berlin, N.W.
1892. Professor Léo Errera. 38 Rue de la Loi, Brussels.
1901. Professor W. G. Farlow. Harvard, U.S.A.
1874. Dr. W. Feddersen. Carolinenstrasse 9, Leipzig.
1886. Dr. Otto Finsch. Leiden, Netherlands.
1887. Professor Dr. R. Fittig. Strassburg.
1894. Professor Wilhelm Foerster, D.C.L. Encke Platz 3A, Berlin, S.W. 48.
1872. W. de Fonvielle. 50 Rue des Abbesses, Paris.
1901. Professor A. P. N. Franchimont. Leiden.
1894. Professor Léon Fredericq. Rue de Pitteurs 20, Liége, Belgium.
1887. Professor Dr. Anton Fritsch. 66 Wenzelsplatz, Prague, Bohemia.
1892. Professor Dr. Gustav Fritsch. Dorotheen Strasse 35, Berlin.
1881. Professor C. M. Gariel. 6 rue Edouard Détaille, Paris.
1866. Dr. Gaudry. 7 bis rue des Saints Pères, Paris.
1901. Professor Dr. Geitel, Wolfenbüttel, Germany.
1884. Professor J. Willard Gibbs. Yale University, New Haven, Conn., U.S.A.
1884. Professor Wolcott Gibbs. Newport, Rhode Island, U.S.A.
1892. Daniel C. Gilman. Johns Hopkins University, Baltimore, U.S.A.
1870. William Gilpin. Denver, Colorado, U.S.A.
1889. Professor Gustave Gilson. l'Université, Louvain, Belgium.
1889. A. Gobert. 222 Chaussée de Charleroi, Brussels.
1884. General A. W. Greely, LL.D. War Department, Washington, U.S.A.
1892. Dr. C. E. Guillaume. Bureau International des Poids et Mesures, Pavillon de Breteuil, Sèvres.
1876. Professor Ernst Haeckel. Jena.
1881. Dr. Edwin H. Hall. 37 Gorham-street, Cambridge, Mass., U.S.A.
1895. Professor Dr. Emil Chr. Hansen. Carlsberg Laboratorium, Copenhagen, Denmark.
1887. Fr. von Hefner-Alteneck. Berlin.
1893. Professor Paul Heger. Rue de Drapiers 23, Brussels.
1894. Professor Ludimar Hermann. Universität, Königsberg, Prussia.
1893. Professor Richard Hertwig. Zoologisches Institut, Alte Akademie, Munich.
1893. Professor Hildebrand. Stockholm.
1897. Dr. G. W. Hill. West Nyack, N.Y., U.S.A.
1887. Professor W. His. Königstrasse 22, Leipzig.
1881. Professor A. A. W. Hubrecht, LL.D., C.M.Z.S. The University, Utrecht, Netherlands.
1887. Dr. Oliver W. Huntington. Cloyne House, Newport, R. I., U.S.A.
1884. Professor C. Loring Jackson. 6 Boylston Hall, Cambridge, Massachusetts, U.S.A.
1867. Dr. J. Janssen, LL.D. L'Observatoire, Meudon, Seine-et-Oise.
1876. Dr. W. J. Janssen. Villa Frisia, Aroza, Graubünden, Switzerland.
1881. W. Woolsey Johnson, Professor of Mathematics in the United States Naval Academy. 32 East Preston Street, Baltimore, U.S.A.
1887. Professor C. Julin. 153 rue de Fragnée, Liége.
1876. Dr. Giuseppe Jung. 19 Via Fatebenefratelli, Milan.
1884. Professor Dairoku Kikuchi, M.A. Imperial University, Tōkyō, Japan.
1873. Professor Dr. Felix Klein. Wilhelm-Weberstrasse 3, Göttingen.

Year of Election.

1894. Professor Dr. L. Kny. Kaiser-Allee 92, Wilmersdorf, bei Berlin.
1896. Dr. Kohlrausch. Marchstrasse 25B, and Physikalisch-technische Reichsanstalt, Charlottenburg, Berlin.
1856. Professor A. von Kölliker. Würzburg, Bavaria.
1894. Professor J. Kollmann. St. Johann 88, Basel, Switzerland.
1887. Professor Dr. Arthur König. Physiological Institute, The University, Berlin, N.W.
1894. Maxime Kovalevsky. Beaulieu-sur-Mer, Alpes-Maritimes.
1887. Professor W. Krause. Knesebeckstrasse, 17/I, Charlottenburg, bei Berlin.
1877. Dr. Hugo Kronecker, Professor of Physiology. Universität, Bern, Switzerland.
1887. Professor A. Ladenburg. Kaiser Wilhelm Strasse 108, Breslau.
1887. Professor J. W. Langley. 77 Cornell Street, Cleveland, Ohio, U.S.A.
1882. Dr. S. P. Langley, D.C.L., Secretary of the Smithsonian Institution, Washington, U.S.A.
1872. M. Georges Lemoine. 76 Rue Notre Dame des Changes, Paris.
1901. Professor Philipp Lenard. Kiel.
1887. Professor A. Lieben. IX. Wasagasse 9, Vienna.
1883. Dr. F. Lindemann. Franz-Josefstrasse 12/I, Munich.
1877. Dr. M. Lindemann. Sennorrstrasse 62, II, Dresden.
1887. Professor Dr. Georg Lunge. Universität, Zurich.
1871. Professor Jacob Lüroth. Mozartstrasse 10, and Universität, Freiburg-in-Breisgau, Germany.
1894. Dr. Otto Maas. Universität, Munich.
1887. Dr. Henry C. McCook. 3,700 Chestnut-street, Philadelphia, U.S.A.
1867. Professor Mannheim. 1 Boulevard Beauséjour, Paris.
1887. Dr. C. A. Martius. Voss Strasse 8, Berlin, W.
1890. Professor E. Mascart, Membre de l'Institut. 176 rue de l'Université Paris.
1887. Professor D. I. Mendeléeff, D.C.L. Université, St. Petersburg.
1887. Professor N. Menschutkin. St. Petersburg.
1884. Professor Albert A. Michelson. The University, Chicago, U.S.A.
1887. Dr. Charles Sedgwick Minot. Boston, Massachusetts, U.S.A.
1894. Professor G. Mittag-Leffler. Djuvsholm, Stockholm.
1893. Professor H. Moissan. The Sorbonne, Paris (7 Rue Vauquelin).
1877. Professor V. L. Moissenet. 4 Boulevard Gambetta, Chaumont, Hte. Marne, France.
1894. Dr. Edmund von Mojsisovics. Strohgasse 26, Vienna, III/3.
1897. Professor Oskar Montelius. St. Paulsgatan 11, Stockholm, Sweden.
1897. Professor E. W. Morley, LL.D. Adelbert College, Cleveland, Ohio, U.S.A.
1887. E. S. Morse. Peabody Academy of Science, Salem, Mass., U.S.A.
1889. Dr. F. Nansen. Lysaker, Norway.
1894. Professor R. Nasini. Istituto Chimico dell' Università, Padova, Italy.
1864. Dr. G. Neumayer. Deutsche Seewarte, Hamburg.
1884. Professor Simon Newcomb. 1620 P.-street, Washington, D.C., U.S.A.
1887. Professor Emilio Noelting. Mühlhausen, Elsass, Germany.
1894. Professor H. F. Osborn. Columbia College, New York, U.S.A.
1894. Baron Osten-Sacken. Heidelberg.
1890. Professor W. Ostwald. Linnéstrasse 2, Leipzig.
1889. Professor A. S. Packard. Brown University, Providence, Rhode Island, U.S.A.
1890. Maffeo Pantaleoni. 20 Route de Malagnou, Geneva.

Year of Election.

1895. Professor F. Paschen. Universität, Tübingen.
1887. Dr. Pauli. Feldbergstrasse 49, Frankfurt a. M., Germany.
1901. Professor A. Penck. Vienna.
1890. Professor Otto Pettersson. Stockhoms Hogskola, Stockholm.
1894. Professor W. Pfeffer, D.C.L. Linnéstrasse 11, Leipzig.
1870. Professor Felix Plateau. 152 Chaussée de Courtrai, Gand, Belgium.
1886. Professor F. W. Putnam. Harvard University, Cambridge, Massachusetts, U.S.A.
1887. Professor Georg Quincke. Hauptstrasse 47, Friederichsbau, Heidelberg.
1868. L. Radlkofer, Professor of Botany in the University of Munich. Sonnenstrasse 7.
1895. Professor Ira Remsen. Johns Hopkins University, Baltimore, U.S.A.
1886. Rev. A. Renard. 6 Rue du Roger, Gand, Belgium.
1897. Professor Dr. C. Richet. 15 Rue de l'Université, Paris, France.
1873. Professor Baron von Richthofen. Kurfürstenstrasse 117, Berlin, W.
1896. Dr. van Rijckevorsel. Parklaan 7, Rotterdam, Netherlands.
1892. Professor Rosenthal, M.D. Erlangen, Bavaria.
1890. A. Lawrence Rotch. Blue Hill Observatory, Readville, Massachusetts, U.S.A.
1895. Professor Karl Runge. Kaiser Wilhelmstrasse 5, Kirchrode, bei Hannover.
1901. Gen.-Major Rykatchew. St. Petersburg.
1894. Professor P. H. Schoute. The University, Groningen, Netherlands.
1883. Dr. Ernst Schröder. Gottesanerstrasse 9, Karlsruhe in Baden.
1874. Dr. G. Schweinfurth. Potsdamerstrasse 75A, Berlin.
1897. Professor W. B. Scott. Princeton, N.J., U.S.A.
1873. Dr. A. Shafarik. Vinohrady 422, Prague.
1892. Dr. Maurits Snellen, Chief Director of the Royal Meteorological Institute of the Netherlands, de Bilt, near Utrecht.
1887. Professor H. Graf Solms. Bot. Garten, Strassburg.
1887. Ernest Solvay. 25 Rue du Prince Albert, Brussels.
1888. Dr. Alfred Springer. 312 East 2nd St., Cincinnati, Ohio, U.S.A.
1889. Professor G. Stefanescu. Strada Verde 8, Bucharest, Roumania.
1881. Dr. Cyparissos Stephanos. The University, Athens.
1894. Professor E. Strasburger. The University, Bonn.
1881. Professor Dr. Rudolf Sturm. Fränkelplatz 9, Breslau.
1884. Professor Robert H. Thurston. Cornell University, Ithaca, New York, U.S.A.
1887. Dr. T. M. Treub. Buitenzorg, Java.
1887. Professor John Trowbridge. Harvard University, Cambridge, Massachusetts, U.S.A.
Arminius Vámbéry, Professor of Oriental Languages in the University of Pesth, Hungary.
1890. Professor Dr. J. H. van't Hoff. Uhlandstrasse 2, Charlottenburg, Berlin.
1889. Wladimir Vernadsky. Mineralogical Museum, Moscow.
1886. Professor Jules Vuylsteke. 21 rue Belliard, Brussels, Belgium.
1887. Professor H. F. Weber. Zurich.
1887. Professor Dr. Leonhard Weber. Moltke Strasse 60, Kiel.
1887. Professor August Weismann. Freiburg-in-Breisgau, Baden.
1887. Dr. H. C. White. Athens, Georgia, U.S.A.
1881. Professor H. M. Whitney. Branford, Conn., U.S.A.
1887. Professor E. Wiedemann. Erlangen. (C/o T. A. Barth, Johannisgasse, Leipzig.)

Year of Election.

1887. Professor Dr. R. Wiedersheim. Hansastrasse 3, Freiburg-im-Breisgau, Baden.
1887. Dr. Otto N. Witt. 21 Siegmundshof, Berlin, N.W. 23.
1876. Professor Adolph Wüllner. Aureliusstrasse 9, Aachen.
1887. Professor C. A. Young. Princeton College, New Jersey, U S.A.
1896. Professor E. Zacharias. Botanischer Garten, Hamburg.
1887. Professor F. Zirkel. Thalstrasse 33, Leipzig.

LIST OF SOCIETIES AND PUBLIC INSTITUTIONS

TO WHICH A COPY OF THE REPORT IS PRESENTED.

GREAT BRITAIN AND IRELAND.

Belfast, Queen's College.
Birmingham, Midland Institute.
Bradford, Philosophical Society.
Brighton Public Library.
Bristol Naturalists' Society.
——, The Museum.
Cambridge Philosophical Society.
Cardiff, University College.
Chatham, Royal Engineers' Institute.
Cornwall, Royal Geological Society of.
Dublin, Geological Survey of Ireland.
——, Royal College of Surgeons in Ireland.
——, Royal Geological Society of Ireland.
——, Royal Irish Academy.
——, Royal Society of.
Dundee, University College.
Edinburgh, Royal Society of.
——, Royal Medical Society of.
——, Scottish Society of Arts.
Exeter, Albert Memorial Museum.
Glasgow Philosophical Society.
——, Institution of Engineers and Shipbuilders in Scotland.
Leeds, Institute of Science.
——, Philosophical and Literary Society of.
Liverpool, Free Public Library.
——, Royal Institution.
London, Admiralty, Library of the.
——, Anthropological Institute.
——, Arts, Society of.
——, Chemical Society.
——, Civil Engineers, Institution of.
——, East India Library.
——, Geological Society.
——, Geology, Museum of Practical, 28 Jermyn Street.
——, Greenwich, Royal Observatory.
——, Guildhall, Library.
——, Kew Observatory.
London, King's College.
——, Linnean Society.
——, London Institution.
——, Mechanical Engineers, Institution of.
——, Physical Society.
——, Meteorological Office.
——, Royal Asiatic Society.
——, Royal Astronomical Society.
——, Royal College of Physicians.
——, Royal College of Surgeons.
——, Royal Geographical Society.
——, Royal Institution.
——, Royal Meteorological Society.
——, Royal Society.
——, Royal Statistical Society.
——, Sanitary Institute.
——, United Service Institution.
——, University College.
——, War Office, Library.
——, Zoological Society.
Manchester Literary and Philosophical Society.
——, Mechanics' Institute.
Newcastle-upon-Tyne, Literary and Philosophical Society.
——, Public Library.
Norwich, The Free Library.
Nottingham, The Free Library.
Oxford, Ashmolean Natural History Society.
——, Radcliffe Observatory.
Plymouth Institution.
——, Marine Biological Association.
Salford, Royal Museum and Library.
Sheffield, University College.
Southampton, Hartley Institution.
Stonyhurst College Observatory.
Swansea, Royal Institution of South Wales.
Yorkshire Philosophical Society.
The Corresponding Societies.

EUROPE.

Berlin	Die Kaiserliche Akademie der Wissenschaften.
Bonn	University Library.
Brussels	Royal Academy of Sciences.
Charkow	University Library.
Coimbra	Meteorological Observatory.
Copenhagen	Royal Society of Sciences.
Dorpat, Russia	University Library.
Dresden	Royal Museum.
Frankfort	Natural History Society.
Geneva	Natural History Society.
Göttingen	University Library.
Grätz	Naturwissenschaftlicher Verein.
Halle	Leopoldinisch-Carolinische Akademie.
Harlem	Société Hollandaise des Sciences.
Heidelberg	University Library.
Helsingfors	University Library.
Jena	University Library.
Kazan, Russia	University Library.
Kiel	Royal Observatory.
Kiev	University Library.
Lausanne	The University.
Leyden	University Library.
Liège	University Library.
Lisbon	Academia Real des Sciences.
Milan	The Institute.
Modena	Royal Academy.
Moscow	Society of Naturalists.
——	University Library.
Munich	University Library.
Naples	Royal Academy of Sciences.
Paris	Association Française pour l'Avancement des Sciences.
——	Geographical Society.
——	Geological Society.
——	Royal Academy of Sciences.
——	School of Mines.
Pultova	Imperial Observatory.
Rome	Accademia dei Lincei.
——	Collegio Romano.
——	Italian Geographical Society.
——	Italian Society of Sciences.
St. Petersburg	University Library.
——	Imperial Observatory.
Stockholm	Royal Academy.
Turin	Royal Academy of Sciences.
Utrecht	University Library.
Vienna	The Imperial Library.
——	Central Anstalt für Meteorologie und Erdmagnetismus.
Zurich	General Swiss Society.

ASIA.

Agra	The College.
Bombay	Elphinstone Institution.
——	Grant Medical College.
Calcutta	Asiatic Society.
——	Hooghly College.
Calcutta	Medical College.
——	Presidency College.
Ceylon	The Museum,Colombo.
Madras	The Observatory.
——	University Library.
Tokyo	Imperial University.

AFRICA.

Cape of Good Hope . . . The Royal Observatory.

AMERICA.

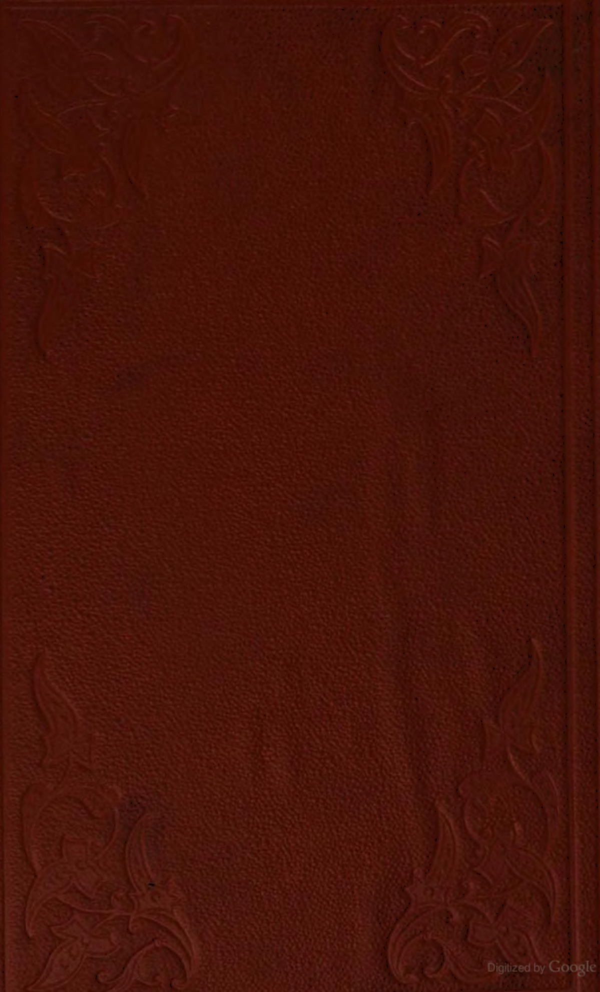
Albany	The Institute.
Amherst	The Observatory.
Baltimore	Johns Hopkins University.
Boston	American Academy of Arts and Sciences.
California	The University.
——	Lick Observatory.
——	Academy of Science.
Cambridge	Harvard University Library.
Chicago	American Medical Association.
——	Field Columbian Museum.
Kingston	Queen's University.
Manitoba	Historical and Scientific Society.
Mexico	Sociedad Científica 'Antonio Alzate.'
Missouri	Botanical Garden.
Montreal	Council of Arts and Manufactures.
——	McGill University.
New York	American Society of Civil Engineers.
——	Lyceum of Natural History.
Ottawa	Geological Survey of Canada.
Philadelphia	American Philosophical Society.
——	Franklin Institute.
——	University of Pennsylvania.
Toronto	The Observatory.
——	The Canadian Institute.
——	The University.
Washington	Bureau of Ethnology.
——	Smithsonian Institution.
——	The Naval Observatory.
——	United States Geological Survey of the Territories.
——	Library of Congress.
——	Board of Agriculture.

AUSTRALIA.

Adelaide	The Colonial Government.
——	The Royal Geographical Society.
Brisbane	Queensland Museum.
Melbourne	Public Library.
Sydney	Public Works Department.
——	Australian Museum.
Tasmania	Royal Society.
Victoria	The Colonial Government.

NEW ZEALAND.

Canterbury Museum.

PRINTED BY
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